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SCIENCE AND OPINION*

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Rodin's statue of "The Thinker" is one of the great pieces of modern art. People gaze upon it with wonder as if they were viewing the figure of a creature belonging to a bygone age. Profound thinking certainly is not an outstanding characteristic of our times. The noise of the propagandist is abroad in the land. Our eyes are dazzled and our ears are deafened by the bombardment of the big guns which are directed at us from every angle. In the confusion of it all, it is easy for the mass of us to surrender our own judgment to the most effective agent of publicity. In fact, it is necessary for the person of independent mind to put forth unusual effort for the purpose of maintaining his intellectual integrity.

If democracy is a government by public opinion, it is important that this opinion shall be liberal, self-controlled, intelligent, and honest. Even the most optimistic would hardly venture to assert that as a people we have attained any high degree of effectiveness in assuring the prevalence of this kind of opinion.

The public schools and the colleges, to be sure, have done much to promote the formation of enlightened opinion; but they have not done enough. In their commendable efforts they have been handicapped by the necessity of teaching a great number of facts because in the public mind the acquisition of

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facts has been confused with education. The pathetic spectacle of young citizens in school diligently (or perhaps carelessly) attempting to assimilate from textbooks and lectures a mass of information to be relayed back to the teachers in recitation or in examination, is one of the most discouraging evidences of our failure to attain the full measure of our possibilities. Facts, to be sure, are essential to all sound thinking. The more facts one has in his possession the better able he is to do creative thinking. Facts, however, are only the raw materials of thinking. Reflection, organization, generalization, are necessary if facts are to have real significance. As our schools continue to improve their techniques of teaching, they will make themselves more effective agents for the development of that intelligent opinion which is so greatly needed in our critical situation.

There is general agreement that the problems which confront America are of the most serious nature. The validity of almost every standard by which we have been governed in the past is now called into question. Economics, morals, government, are all in such an unsettled state as to leave us in a condition of the greatest perplexity. We alternate between spasms of fear and ecstasies of hope. Nobody feels comfortable; nobody is sure of tomorrow. Under these conditions there are at least four courses open to us. We may affect an attitude of indifference; we may bend our efforts towards the restoration of old conditions; we may accept the theories of radical leaders who find in this situation of unrest a condition altogether to their liking; or we may with calm, deliberate judgment think our way through these problems and map out a course of action in harmony with our conclusions.

This latter course, as I understand it, is the way of science. The old Baconian method of induction has not been superseded. We begin with an observed phenomenon; we formulate a tentative hypothesis to explain this phenomenon; we make more observations and gather more facts; we revise or we confirm our original hypothesis on the basis of the new facts and new observations; we generalize the entire process in terms of a law or principle. This procedure gives no place to the closed mind, to indifference, to preconceived notions, or to prejudices. Intellectual curiosity and alertness, absolute intellectual honesty, an open mind, and a willingness to follow wherever established principles may lead, are indispensable essentials in the scientific treatment of any problem. If all of our people had

this scientific attitude of mind, many of our difficulties could be surmounted with comparative ease.

It is Utopian to expect that at any time in the near future the method of science will be accepted as a universal rule of conduct. In fact, the whole set-up of our social and political institutions conduces to an unscientific approach to our problems. Doubtless the greatest single obstacle to the adoption of the scientific method is self-interest, real or imagined. We have built up through the years certain vested rights which we do not wish to see disturbed. By vested rights I do not refer solely to those privileges which ordinarily are associated with the possession of wealth. There are many other vested rights which we seek to preserve. In general, a vested right may be defined as the right to continue to do things as we always have done them. In a school system, for example, it is the vested right of the head of a department to teach the particular phases of a subject that are to her own liking. It is the vested right of a dean, or a principal, or a superintendent, to continue to exercise certain privileges and prerogatives which have grown up about his office with the passing of time. Whether these rights are socially useful, fair, or just, will not be given first consideration. The supposedly vested rights of cattlemen on the plains led to bitter conflicts when the sheep-herders attempted to avail themselves of grazing privileges. Paraguay and Bolivia recently have gone to war to establish title to a territory which each has claimed as its own.

Another obstacle to scientific thinking is found in deep-seated prejudice. This may be racial, religious, social, economic, or political. Prejudice effectually closes the mind to new ideas. If I am a high tariff advocate, I can see nothing good in free trade or in tariff for revenue only. If I am a pronounced nationalist, I can see nothing good in a world court or in a league of nations. If I am a pacifist, I can find no justification for an army or a navy. Whatever preconceived notions I accept, are habits of thinking that prevent me from giving fair consideration to other views.

Dishonesty and ignorance are additional barriers to scientific thinking. Until the millennium arrives, these two will always be with us. The dishonest man must be exposed to public contumely. The ignorant man must be informed. This latter task is the work of education.

It takes no lengthy argument to convince us that public

opinion is a very curious thing, uncertain in its quantity, unpredictable in its consequences. One eminent writer has gone so far as to say that there is no such thing as general public opinion; that there is only a great number of public opinions all different from one another according to the constituency of the groups which formulate and hold them. An ignorant group, for example, is not likely to hold opinions similar to those of a well-informed and intelligent group. The ignorant will believe in charms, in signs, in notions handed down by tradition. They will use the mysterious "they say" as an excuse for spreading idle gossip or for destroying reputation and vilifying character. Every other group will have its own special characteristics.

When we think of our social situation in this way, it becomes increasingly apparent that we have a most difficult problem in America when we attempt to arrive at sane conclusions and to enter upon a course of concerted action. And yet as if by some magic, we do seem to arrive at a common point when emergency presses in upon us. As long ago as 1843, Job Durfee in his Phi Beta Kappa address at Brown University, gave expression to a thought which may be comforting in our own day. "Public opinion, in our country," he says, "indulges in no abstract speculations: it leaves them to the dreams of the theorist. In the full enjoyment of its own unobstructed freedom, it is never clamorous, it is never violent. It moves only on great occasions, and under the pressure of some stern necessity; but, when it does move, it is irresistible; it bears down all opposition before it."

If the propagandists and publicity agents find it useful for their own purposes to make vigorous efforts to guide and to control public opinion, it would seem that the end to be attained is of considerable importance. By the very nature of its calling, the teaching profession cannot have the aims or use the means of those who have personal interests to establish. For purely social ends, however, teachers have a binding obligation to train their pupils from the earliest years of school through to the end of formal education in habits of scientific thinking. This obligation is not limited to the teachers of the subjects known under the name of science. It is not limited to teachers of physics and chemistry and biology and of the other subjects classified as science. The teachers of these branches, to be sure, have unusual opportunities for teaching the scientific method. For that reason they have an unusual obligation to

perform their task well. Teachers of all other subjects, however, will do their best work only when they strive to arouse in their pupils the alert, honest, open, and fearless mind.

The function which the schools can perform in making the scientific method the basis of public opinion is two-fold. In the first place, through the use of the proper materials and techniques of teaching, the schools may provide a broad base of general intelligence among the people—an intelligence that is alert, honest, and fearless. We must assume, however, that for long periods of time, as long, in fact, as we can now peer into the future, there will be a need for leaders of thought and for intelligent followers. The great mass of the people, no matter how well-educated and how honest they may be, will be helped in meeting both personal and community problems by the guidance of those who have greater wisdom than their own. This does not mean that at any time people should blindly follow leaders. It is against this blind following that scientific method will protect us. Nevertheless, a part of education consists in learning how to accept the leadership of those who know more than we do. When we are ill, we consult a physician. When we have financial problems, we consult a banker (or we used to); when we have to appear in the courts, we consult a lawyer. There is need of the acceptance of superior learning and superior wisdom in all fields of human activity. The scientific mind will be as ready to accept leadership sensibly as the ignorant mind has heretofore accepted or rejected it blindly.

The second function of education is to increase the number of those who are able to provide intellectual leadership and who are willing to use the method of science in attaining their ends. Doctor Karl T. Compton in a recent address before the American Association for the Advancement of Science, is quoted as saying the following: "One of the fundamental laws of physical science, the second law of thermodynamics, shows that nature in all her aspects moves toward chaos unless directed by an intelligent hand. It is a significant fact that in physical science, only one way has ever been suggested by which the tendency toward chaos can be circumvented. In slang phrase, there is only one way to 'beat' the second law of thermodynamics. This way is by exercise of the intelligence in carrying out a planned policy." Very few, I take it, would dispute Doctor Compton's qualifications for making such a statement. Most of us will accept his application of this law

of physical science to the field of social organization.

We hear much discussion about the meaning of democracy. To some minds the term seems to imply the absolute equality of all men; that one man is as good as another. Some unfortunate consequences have followed upon the acceptance of this view. It has made many people, for example, unwilling to accord the rightful place to able men. This equalitarian view tends to pull all men down to a common level. You will recall what James Truslow Adams said about John Quincy Adams. A man of fine culture, of steadfast devotion to his country, of masterly qualifications for high office, he seemed too far beyond the crowd to meet their full approval. They gave their plaudits and their ballots instead to Andrew Jackson, a good man who was more like themselves.

We are recognizing now that the equalitarian view of democracy is an impediment to progress when it means other than absolute equality of right before the law. The method of science has demonstrated clearly that in other respects men are quite unequal. Consequently, then, the method of science teaches us to face the facts squarely and to recognize that a democracy involves both leaders and followers. The public opinion on which the operation of a democratic system of government depends, functions most adequately when the great masses of the people are educated in such a manner as to make it possible for them to know who are true leaders and who are false; to be able and willing to reject the false and to accept the true. At the same time, the successful functioning of democracy will depend upon the existence of a large number of leaders who have mastered the true method of science and who have the desire to put their fine qualifications at the service of society. An effective system of public education will provide well-trained followers and high-minded leaders.

ACID-RESISTING CEMENT MADE OF SULPHUR AND SAND

Cement made of 40 per cent sulphur and 60 per cent sand mixed while the sulphur is in a molten state is finding increased uses in industry. Because such sulphur cements are highly resistant to the action of acids, particularly sulphuric acid, they are finding uses in structures subjected to corrosive liquids and films. Among the new uses suggested are: acid-resistant floors and walls; sewers and drains, ventilating shafts, chimneys and flues; and for coating brickword where acid vapors condense.

A PRACTICAL THREE-DIMENSIONAL GRAPH

BY FRANKLIN MILLER, JR.
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The purpose of this paper is to describe a fairly simple and convenient method for construction of three-dimensional graphs. The construction makes use of calculated or observed contour-lines, and in the final result the contour-lines are physically very much in evidence.

The procedure consists essentially of cutting out of stiff cardboard sheets which I shall designate as "contour sheets." Supposing that it is desired to construct z as a function of x and y, data is obtained from experiment or by calculation, and suitable ranges for the variables are decided upon. With one variable held constant (say x), graphs are constructed, one for each value of x, which show the variation of z with y. These graphs become contour-sheets when sheets of stiff cardboard are cut out with the upper boundary of each corresponding to a graph of z against y. When a set of "x-contour-sheets" and "y-contour-sheets" has been made, they are interlocked in the manner described below, giving the complete graph.

An example will make the method clear: It is wished to plot z against values of x and y, the variables taking on values $x=0, 1, 2, 3, 4$, and $y=0, 1, 2, 3, 4$. Ten contour-sheets are constructed, each corresponding to a given value of x (or y), showing the variation of z with y (or x). Fig. 1 shows the $y=3$ and the $x=2$ contour-sheets, and it will be noted that the points C and C' correspond to the same value of z, namely, that for $x=2$ and $y=3$. Similar considerations apply to each ordinate in the completed graph.

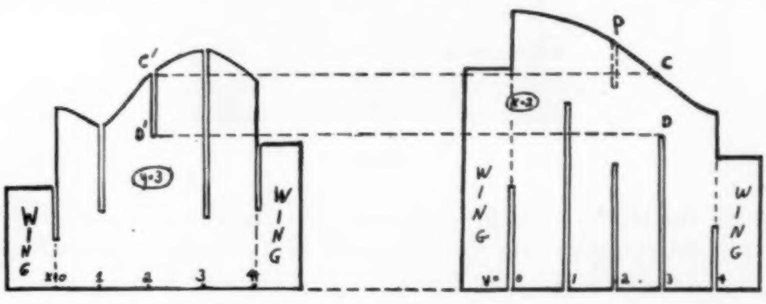

FIG. 1

The practical method of interlocking the contour-sheets is this: The $x=2$ and $y=3$ contour-sheets are superposed, care being taken that the points C and C' coincide. A pin-prick is made at any suitable point D—D' and slits are made in the two sheets as shown (from the bottom upwards in the x-sheets and from the top downwards in the y-sheets). A slit is thus made for each pair of x and y values (each time in the proper pair of contour-sheets) until there are the total of 25 slits. (In Fig. 1 it will be seen that on each sheet must be left rectangular "wings" so that all the slits can be made.)

The set of contour-sheets is assembled much as is a cardboard egg-carton. One way of doing it is to arrange all the y-sheets at the proper spacing, and then slip each x-sheet down,

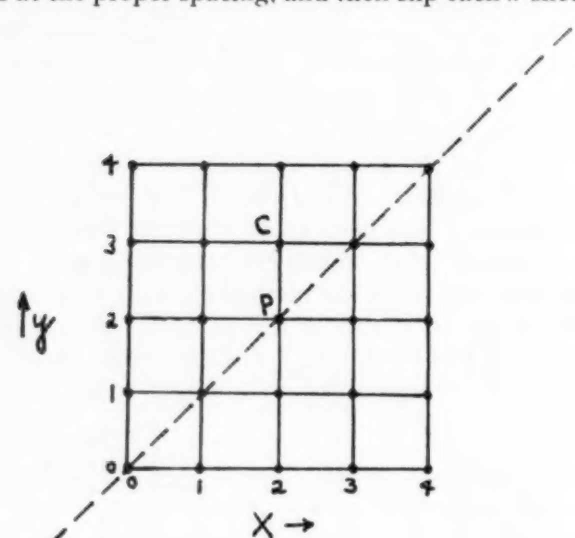

FIG. 2

with the slits interlocking. In Fig. 2 is shown the base of the completed figure, the intersections of the lines representing points of the graph, the horizontal and vertical lines representing the x- and the y-contour sheets, viewed from above.

The completed figure will be collapsible, and to give it rigidity a "diagonal-sheet" may be introduced as indicated in Fig. 2. It must be superposed in turn on each x-sheet, and the proper slits made in the x-sheets where the diagonal intersects. (There will thus be one additional cut in each x-sheet, always at points where $x=y$, of course.) No cut need be made in the

y-sheets. The diagonal-sheet may be removed at any time, and the graph folded together for storage. However, the x- and y-contour-sheets remain interlocked, and the graph may be viewed simply by extending it without the aid of the diagonal-sheet.

In the actual construction of such a graph, the following hints may be of use: Be sure the slits are wide enough—they should be equal in width to the thickness of cardboard used. The contour-sheets will be less liable to tear if the cuts in any given sheet are staggered, as shown. Each sheet should be labeled upon its surface, and the x- and y-coordinates marked along

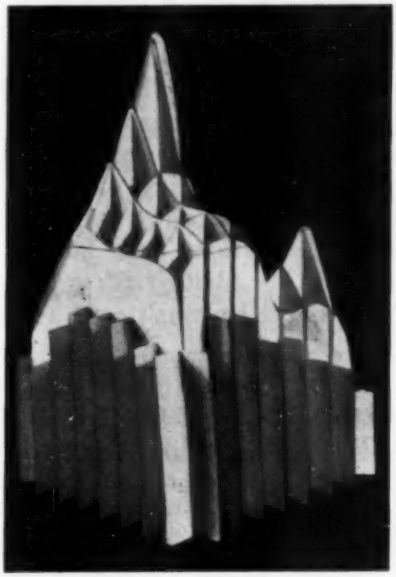

FIG. 3

the lower edge of each. In preparing the contour-sheets, a good method is to lay out the points on squared paper, and cut out the cardboard with the aid of pin-pricks. Sheets should be spaced about a centimeter apart in the completed graph, which means that if (as in the illustrative example) there are 5 values of each coordinate used, the base will be about 5 centimeters square. Thus if the graph is being plotted from *calculated* values (e.g., $z=2xy$) it is desirable to locate a large number of points if it is desired to have a large graph.

The completed graph may be filled with plaster-of-Paris or paraffin if it is desired to have a permanent model.

The uses of such graphs are fairly obvious. In the experimental sciences, it is often desired to graph a quantity which can be made to depend upon *two* independent variables. In mathematical economics there has been a demand for such a construction, and for this work the method outlined above enables contour-sheets to be removed and replaced at will, a highly desirable feature.

In the classroom, the less easily visualized surfaces of solid geometry may be constructed readily, as well as surfaces of solid analytic geometry of high orders. In such cases it is merely necessary to calculate from the given equation the requisite number of z-ordinates, and the representation may be made as nearly continuous as desired simply by calculating a large number of points. In school work, this construction has the advantage that the idea of contour-lines of a surface is brought out prominently, and indeed forms the basis of the method.

The graph shown in the accompanying photograph was constructed in connection with study of emission from a hot filament, and the high peaks and low valleys seen in the graph shows that certain observations must have been faulty, and hence can be rejected. The photograph was very kindly made by Mr. W. A. Wallis of the University of Chicago.

LESS LIVER DAMAGE WHEN OXYGEN GIVEN WITH ETHER AND CHLOROFORM

Oxygen is an important factor in preventing the liver damage which may result from certain anesthetics, Drs. S. Goldschmidt, I. S. Ravdin and Baldwin Lucke of the University of Pennsylvania School of Medicine have found.

Combine oxygen instead of air with the anesthetic given during surgical operations, they recommended in reporting their findings to the National Association of Nurse Anesthetists.

They compared the occurrence of necrosis or damage to the liver cells with dogs anesthetized with chloroform, with the familiar ethyl ether and with a new anesthetic, not yet on the market, divinyl ether.

Chloroform produced liver damage after the dogs had been under its influence for an hour. The occurrence of liver damage was ten times as great when air was used to volatilize the chloroform as when oxygen was used.

With divinyl ether, liver damage did not appear with any degree of regularity until the animals had been under the anesthetic for three hours. Using oxygen instead of air to volatilize this anesthetic reduced the occurrence of liver damage by one-half.

Under unfavorable circumstances, that is, when the inspired air has a low oxygen content, the Philadelphia scientists found that even ethyl ether, the kind ordinarily used in operations, produced liver changes.

SOME SUPPLEMENTARY CHEMICAL EXPERIMENTS

By Charles H. Stone
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In every chemistry laboratory division, there are always a few pupils who are capable of doing much more than the set requirements of the course. They are eager and enthusiastic. To such pupils, the teacher may wish to assign additional experimental material. It has been the writer's experience over a good many years of teaching, that such additional experimental material should be novel in character, differing more or less from the usual laboratory work, and that the pupil should have something tangible to show for his effort. These experiments should call for an application of what he has learned in his preceding laboratory work.

From a list of over one hundred such experiments, a few have been selected for this present article. These have been repeatedly tried out in the author's classes and will work without fail. There is no danger attached to any one of them. The experiments have been collected from a great number of sources; some of them are original with the writer. An attempt has been made not to include experiments commonly found in preparatory chemistry manuals.

It has been found that much interest is added to this work if the pupil, after he has finished a series of connected experiments, prepares an exhibit of his work. Pains have been taken to select experiments in which some tangible product is obtained. Such products, suitably mounted, make an attractive display and very often excite interest on the part of other students who are thus stimulated to undertake some of this additional work.

For exhibition purposes, sheets of cardboard about 12×18 inches are used. The cardboard should be colored a soft brown or gray. At the top of the sheet is printed with rubber type the title of the exhibit. Below this is a picture, preferably colored, relating to the topic in hand. Such pictures may be found in the advertising pages of the various magazines and trade journals. Beneath the picture are arranged the specimens which the student has prepared. If, for example, the subject is copper and its compounds, the exhibition sheet may show: maps of countries or states producing copper; pictures showing

the mining and transportation of the ore; pictures showing the separation of the metal from its ores; samples of ores; drawings showing the refining of copper by electrolysis; small test tubes containing specimens of copper compounds prepared by the student. Other material may, of course, be included at the teacher's suggestion. Such an exhibition sheet, when neatly done, is quite attractive and should be displayed in the corridor of the school or in some display cabinet. The pupil's name should always be attached to the exhibit and interest is added if a small Kodak picture of the pupil is included.

For mounting the exhibits, the following method will be found satisfactory. Solid specimens prepared by the student should be finely powdered and perfectly dry; in case it is desired to show crystal form or color, the powdering should be omitted. Small test tubes, about $3 \times 3/8$ inch, are satisfactory. These should be tightly stoppered and the corks cut off flush with the rim of the tube. Tubes are best attached to the cardboard as follows: With a ruler and pencil draw a 3 inch line along the axis of the tube and in the position in which it is to lie. Along this line, using a 1/4 inch chisel make an incision half an inch from the lip of the tube and half an inch from the closed end. Cut a strip of mending tissue 1/8 inch wide and two or more inches long. Fold the strip with adhesive side out and insert the two ends through the cut. Bend one end over, moisten it, and press it against the back of the card. Insert the tube through the loop thus made, draw the other end of the tape tight, moisten it, and stick it to the back of the card. If the tube is to rest in a vertical position, only one strip of the tape need be used; if in the horizontal position, two strips will be necessary. Liquids should be thus supported only in a vertical position.

The following experiments have been taken at random from the author's list. They do not form a sequence, since each experiment below is just an isolated instance to show the kind of work these experiments cover.

Chemical Change; a Young Volcano

Fill a small crucible with powdered ammonium dichromate, heaping the material up to a cone shape in the center. Cut off the head of a match as near the chemical part as possible and press the head down into the center of the cone and flush with its surface. Stand the crucible on a tripod and the tripod in

the center of a large sheet of newspaper. Ignite the match head. What happens? Two of the products of the decomposition are water and nitrogen which, of course, escape as invisible vapor and gas. The visible product is chromium oxide, Cr_2O_3, which should be preserved as it will be used in the preparation later of potassium chromate. Compare the solubilities in water and the colors of the original and the final material. What kind of change must have occurred?

Recovery of Materials from Heated Oxygen Mixture

Get six tubes in which oxygen mixture (potassium chlorate and manganese dioxide) has been heated to produce oxygen. Heat each tube strongly, testing with splint carrying a spark, until absolutely sure that no more oxygen can be obtained from the material. Let the six tubes cool. When well cooled, fill each tube with hot water and let stand for five minutes. Then shake each tube well and pour out the contents into an evaporating dish. Rinse out the tubes and add the rinsings to the material in the dish. Heat the dish with stirring of the material. Filter and wash residue on filter with hot water till a sample of the filtrate gives no test with ONE drop of silver nitrate solution. Dry, powder, and preserve the recovered material. The first filtrate should be evaporated to dryness, using low heat toward the last to avoid spattering. Powder and preserve the material. What are the two materials?

Preparation of a Medicinal Salt; Epsom Salts

Warm 20 ml dilute sulphuric acid, and stir into the acid powdered magnesium carbonate as long as effervescence continues. Add a slight excess of the carbonate. When sure that all of the acid has been neutralized, add 10 ml hot water, stir, and filter into a crystallizing dish. Set aside for several days. When a good crop of crystals has formed, drain off the liquid, and transfer the solid material to a filter and drain as dry as possible with suction. Finish drying on sheets of blotting paper or filter paper. Put up a sample at once as the substance is efflorescent. What is the equation?

Watching Crystals Grow

In a small beaker dissolve 10 grams of powdered oxalic acid in as little hot water as possible. Keeping the liquid hot, but not boiling, cautiously add ammonium hydroxide (dilute)

until a drop of the liquid indicates a faint alkaline reaction. Remove the beaker to a sheet of white paper and watch it as it cools, using a hand lens. Presently, crystals will be seen coming out of the liquid and finally almost the whole mass will become crystallized. What are the crystals? Write the equation. Filter off, drain, dry, and preserve a sample.

Spangles of Lead Iodide

Prepare some lead iodide by treating a solution of 5 grams lead nitrate with potassium iodide solution to complete precipitation. Filter off, wash with cold water, and transfer the precipitate to a flask with 50 ml hot water. Keep near the boiling point, while preparing apparatus for the final step. Fit a filter paper to a funnel and stand the funnel in a 50 ml graduate. Warm funnel and graduate by pouring hot water into the funnel till the graduate is full. Throw away the hot water. Now filter the material in the flask into the graduate. Let the graduate stand for some time. Presently spangles of brilliant yellow will be seen forming in the liquid. Practically all of the lead iodide will come out of the solution. Is lead iodide soluble in cold water? Is it very soluble in hot water? Preserve a sample of the spangles.

500 Grams of Barium Chloride!

Weigh out the computed amount of barium carbonate to make 500 grams of the above salt. Put the carbonate in a large evaporating dish and slowly stir in dilute hydrochloric acid until effervescence ceases. Avoid excess acid but all of the carbonate should be dissolved. If a white product forms in the bottom of the dish, add enough hot water to dissolve it with stirring. Add a little carbonate to destroy any slight excess of acid. Heat to boiling to expel carbon dioxide, and filter hot into a large dish. Let stand over night. In the morning drain off the mother liquor and evaporate again for a second crop of crystals. Dry the first crop of crystals. Continue the above process until the volume of liquid becomes too small to bother with. Hand this liquid to the teacher. Combine all of your crystals and when they are well dried, weigh them. Do they weigh 500 grams? If not, how do you explain the loss? Put up a sample and hand the rest of your product to the teacher.

With regard to this experiment it may be said that the quality of the product, while not C.P., is nevertheless good

enough for ordinary laboratory use. The greater portion of the student's product should be placed in a bottle, properly labelled and bearing the name of the student. This material may be used by other students whenever solid barium chloride is needed.

Solid Alcohol

Make a saturated solution of calcium acetate by adding the powdered material slowly with shaking to 50 ml water in a flask. Be sure the solution is saturated, otherwise the experiment will not work. Put 10 ml alcohol into a graduate and add a bit of some dye. This is not necessary but makes the product more attractive. Put 2 ml of your calcium acetate solution into a test tube or small graduate. Pour the liquids from both graduates together into a small beaker or evaporating dish. After one minute what has happened? How do you explain the result? Remove some of the jelly to an iron sheet or base of a ring stand and ignite it. What is the remaining ash?

Milk from Mexico

Latex for this experiment may be obtained from almost any of the large rubber manufacturing plants. Put 10 ml latex into a small beaker, stir with the finger, and gradually add dilute acetic acid. When no more rubber forms, wash and dry the product. Preserve a sample.

A Beginning for Dye Manufacture

Into a clean round-bottomed sandbath or crucible of iron put 8 grams of sodium nitrate and 20 grams of clean sheet lead cut into small pieces. Stand the dish on a ring of the ringstand without asbestos gauze under it. Heat the dish strongly. Holding the dish firmly with the tongs, stir the contents with an iron stirrer. A color change will presently be seen. How do you account for this? What is the equation? Continue the heating and stirring for 15 minutes, or until there is no further deepening of the color. Let the dish cool. Now heat to boiling 50–60 ml water in a flask. When the dish is sufficiently cool, pour the hot water cautiously (look out for steam!) into the dish. Heat the dish again until with stirring the mass disintegrates and the bottom of the dish feels smooth under the end of the stirrer. Filter and wash with much hot water, reserving the first filtrate. Dry and powder the product on the paper and sift

through fine cheese cloth to remove particles of unchanged lead. Preserve a sample of the lead oxide.

Evaporate the first filtrate until there is no further diminution in volume and a little of the material on the end of a stirring rod solidifies on cooling. Pour the melt into a small test-tube and let stand till quite cold. A solid stick of white sodium nitrite should form. This may be used in the preparation of a number of the diazo dyes. Preserve the sample for use.

Preparation of a Dye. Orange II

Sulphanilic acid and b-naphthol may be prepared according to directions in any good organic chemistry manual, if they are not available in the supply room stock of the school.

Dissolve 6 grams anhydrous sodium carbonate in 100 ml water and add 20 g. sulphanilic acid. Shake gently until complete solution results. Add 8.5 g. of sodium nitrite (use that just made above). Cool the liquid down to 20 deg. C by addition of small amounts of ice. Now add a cold solution of 12 g. con. sulphuric acid in 75 ml water. Keep this liquid mixture as cool as possible. For convenience this is best done in a flask surrounded by ice water. Dissolve 16.5 g. b-naphthol (or a-naphthol which gives a different shade) in 100 ml water containing 9.5 g. solid sodium hydroxide. Cool. Into this solution, pour slowly with stirring the liquid from the flask. Stir thoroughly and let stand over night. In the morning filter off, drain, and dry the resulting dye. When dry, powder and sift through fine cheese cloth to remove any small lumps. BE SURE THE DYE IS DRY BEFORE POWDERING AND SIFTING. Save the filtrate from the above.

Dyeing with Orange II

Wet out thoroughly with water a small skein of wool (white) or an old faded silk scarf or any similar material of white or pale color. Every spot of the goods must be wet.

Dilute some of the filtrate with water and heat in a large beaker. Immerse the wet-out goods in the dye bath and keep them in motion until the liquid boils. When the desired shade is obtained, remove the goods, rinse well with water and dry. The depth of color on the goods will depend of course on how much dye was in the bath.

Preparation of Aniline Hydrochloride

Put 10 grams of aniline into a small beaker and surround

the beaker with cracked ice. Slowly stir in 10 ml con. hydrochloric acid. Let the beaker stand in the ice until all heat of reaction has disappeared. Filter, drain, dry, and powder the product.

PREPARATION OF A DYE FROM ANILINE HYDROCHLORIDE

Dissolve 5 g. aniline hydrochloride in 25 ml water, add 2 g. sodium nitrite dissolved in a little water, and make slightly acid with con. hydrochloric acid. Keep the liquid cold.

Dissolve 5 grams b- or a-naphthol in 25 cc water containing just enough sodium hydroxide to cause complete solution. Pour the aniline hydrochloride solution slowly with stirring into the naphthol solution. Stir well. Let stand over night. Filter off, drain, dry, powder and preserve the dye. Try the effect of the filtrate on some wet-out white wool yarn, heating slowly to boiling in a beaker or flask. Wash and dry the sample.

A SINGLE FORMULA FOR THE CONCAVE AND CONVEX LENSES TAKES PLACE OF FOUR OTHERS

By A. V. Pershing

613 East Twelfth Street, Bloomington, Indiana

For convex lens we have: $\frac{1}{q}+\frac{1}{p}=\frac{1}{f}\cdot$ (1)

For concave lens with converging light we have:

$$\frac{1}{q}-\frac{1}{(-p)}=\frac{1}{f}; \qquad -\frac{1}{p}-\frac{1}{q}=-\frac{1}{f} \text{ or } \frac{1}{q}+\frac{1}{p}=\frac{1}{f}\cdot \tag{2}$$

For convex lens with converging light we have:

$$\frac{1}{q}-\frac{1}{p}=\frac{1}{f}\cdot \tag{3}$$

For concave lens we have:

$$\frac{1}{q}-\frac{1}{p}=\frac{1}{f}\cdot \tag{4}$$

(1) and (2) are identical.
(3) and (4) are identical.

Both sets are of the same form with the exception of the second sign.

In case (1) the light diverges, then converges or attempts to do so.

Write: Diverge—Converge

D — C

D and C are unlike. Write U for unlike.

With (1) therefore we associate U.

In case (2) the light is converging, then diverges or attempts to do so.

Write: Converge—Diverge

C — D

C and D are unlike. Write U for unlike.

With (2) we also associate U.

(1) and (2) also have the same formula:

$$\frac{1}{q}+\frac{1}{p}=\frac{1}{f}. \qquad U\text{-cases.}$$

In case (3) the light converges, then continues to converge.

Write: Converge—Converge

C — C

C and C are alike. Write A for alike.

With (3) we associate A.

In case (4) we have diverging light, then the light continues to diverge.

Write: Diverge—Diverge

D — D

D and D are alike. Write A for alike.

With (4) we associate A.

(3) and (4) are alike in formula, namely:

$$\frac{1}{q}-\frac{1}{p}=\frac{1}{f}. \qquad A\text{-cases.}$$

For U-cases $\frac{1}{q}+(U)\,\frac{1}{p}=\frac{1}{f}$.

Use + for U or U-cases.

For A-cases $\frac{1}{q}-(A)\,\frac{1}{p}=\frac{1}{f}$.

Use − for A or A-cases.

Combining we get:

$$\frac{1}{q} \pm \left\{\frac{U}{A}\right\} \frac{1}{p} = \frac{1}{f}, \text{ using } + \text{ for } U\text{-cases and } - \text{ for } A\text{-cases.}$$

Remembering this we have finally:

$$\frac{1}{q} \pm \frac{1}{p} = \frac{1}{f}.$$

This formula may also be used for problems with convex and and concave mirrors.

A CLEARER UNDERSTANDING OF THE FRUIT-SEED RELATIONSHIP THROUGH THE USE OF THE FRUITS OF WILD INDIGO

By P. A. Davies
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It is often difficult, with the botanical material used fork demonstration or in the laboratory, to give to the student a clear understanding of the fruit-seed relationship. The material used is either too small or it does not clearly indicate the parts needed to be studied. The writer has used the fruits (pods) of species of wild indigo with very good results. The fruits are large in most species, they can be easily handled, and the structures clearly observed. The calyx is persistent, so the student can easily determine the position of the corolla.

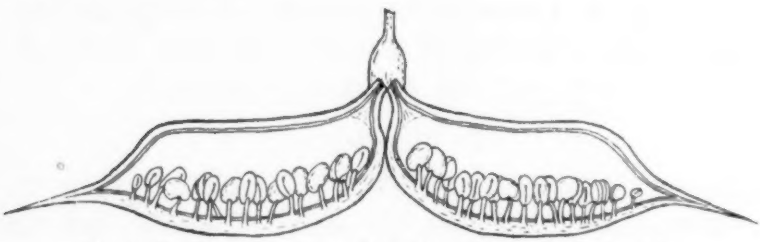
By application of a small amount of pressure to the upper and lower surfaces, the fruit splits easily along the two sutures, dividing the fruit into two halves without damaging the inner structures. On separating the two halves, the distinguishing fruit-seed structures within the fruit-coat can be easily observed (shown in the figure).

Thin sections may be cut, without the use of pith, through the fruit-coat (pericarp), and an examination with a hand-lens or a microscope will reveal the layers of the fruit-wall (exocarp, mesocarp, and endocarp).

As the pistil of the flower consists of but a single carpel, whose margins are united in such a way that the ovary incloses a single cavity (the locule), the origin and the position of these

parts can be easily explained. The placenta, to which the seed-stalks (funiculi) are attached is clearly shown by a thickened mass just above the lower suture. The funiculus is long and bears at its apex the seed. By removing the seed from the funiculus, the external features of the seed, such as, the hilum, raphe, and micropyle may be observed.

The writer has found the fruits of the wild white indigo, *Baptisia leucantha*, to be the best. If this species of wild indigo is not endemic to the locality, other species found in the locality may be used successfully. A supply of the fruits may be assured by planting the seeds in the garden or on waste land where there is not too much shade. The plants grow very favorably under cultivation.



The fruit split in half, showing the fruit-seed relationship.

The fruits should be gathered during June or July while they are still green. A good preservative which will retain the green color and at the same time will not cause a softening of the fruit is as follows:

Alcohol (50 per cent)	93 cc.
Formaldehyde	5 cc.
Acetic acid (glacial)	2 cc.
Copper chloride	6 grams
Uranium nitrate	1 gram

The material may be preserved in 60 per cent alcohol or a solution of 5 per cent formaldehyde and 2 per cent glacial acetic acid. The greatest disadvantage of using the last two preservatives is their tendency to bleach the material. Regardless of the preserving fluid used, the cavity inside the fruit-coat should be filled with the preserving fluid before the fruit is placed in the container of the preserving fluid. An opening should be made in the fruit-coat and the fluid forced in through a glass pipette by means of a rubber bulb.

HIGH SCHOOL AND COMMUNITY*

Questioning Certain Prevailing Practices

By Otis W. Caldwell

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A train connection I needed to make a few weeks ago caused me to drive across a county in one of the Central States. It was early in the day, and school busses were gathering boys and girls for the county seat high school. This school has about 1000 pupils from the surrounding towns, villages and rural regions. The county's lecture and musical program centers at the high school auditorium. The athletic interests of the county center in the high school gymnasium and open field. Much of the county's intellectual stimulus comes from and goes to its high school. Here all church, political, social and industrial groups meet on common ground. Whatever the future of the boys and girls may be, their present community interests center in, and radiate from, this large central high school. The United States high school, varying greatly in different communities, is a modern community agency, for which the human race has had no precedent. The preparatory school was set up for, and dominated by, purposes quite unlike those that have become conspicuous in our most representative secondary schools. Is this modern high school truly serving the children of its community?

I propose to question certain major, prevailing, and presumably approved ideas and practices in public secondary schools. I propose also to make specific suggestions of ways in which some of these questioned practices may be improved. Much of what is advocated is not new in statement, but is still so new in practice as to demand added comment.

I. *The first question raised is whether the high school can render its best service by continuing to be so largely a school of languages?*

A few days ago, a father and his daughter called for a conference about the daughter's further education. This girl has completed half of her required high school work in a well-known and highly approved Eastern public high school. Each year

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* A paper presented before the Joint Session of the Department of Secondary Education and Science Instruction of the National Education Association at Washington, D. C., July 2, 1934.

she has studied English, Latin and French. In addition, she has had one year in fine arts, one in history, and one in science; she also has had two years in mathematics. Her school marks are good. She will be expected to continue her three languages next year, and has even considered beginning a second modern foreign language. She asked what other subjects would probably prove most valuable to her. Her parents are poor. Under existing circumstances, the daughter does not see how she can have money by means of which to go to college. The family is ambitious to have her go to college, not now having any particular college in mind. If this young lady completes her high school work as now planned she will have devoted between three-fifths and three-fourths of her high school time to languages. If she then goes to college, she will be expected to continue English and probably at least one foreign language and also may even continue Latin.

Persons who do not like certain implications of the example I have given will make either of two kinds of answers. First, that it is not a typical case; or second, that high school pupils really should give the larger part of their time to language study.

To the first answer it may be said that the case cited is typical of something like one-half of all high school pupils; also that there are thousands of cases where pupils devote even more time to languages than in this case. The printed reports by the National Survey of Secondary Education and other published studies, provide supporting statistics showing how extensively languages prevail in the programs of secondary pupils. Even with the differentiated vocational curricula provided in many comprehensive high schools, the preponderance of the languages remains conspicuous in the total high school situation.

The second answer is very significant, namely, that the languages really should hold so large a part in the pupil's high school time. This is a serious assertion and is believed by many intelligent educators. Indeed, many language teachers, when reference is made to the inefficiency of language teaching, reply that desired improvement in use of languages can be had only by still further increases in the amount of time devoted to language instruction. That is, if what we are now doing fails to produce the desired results, the recommended cure is that we provide more time for a larger amount of the same kind of

work. This contention by language advocates is unproved. It sounds too much like the contentions of vested interests in industry and finance, which almost always suggest further extension of vested interests as the cure for economic and industrial ills. Possibly a different way of doing things might be better, instead of continuing the present vested language interests.

Is not a more promising way of improving language instruction likely to be found by increase in the attention given to the use of language in connection with the idea and thought subjects with which the curriculum and the community must deal? This would involve large reduction in the time devoted to separate instruction in language. In its fundamentals, language is for the purpose of handling ideas and occurrences in effective and graceful manner. Why, then, do we continue the sharp separation between language instruction on one side, and the thought subjects such as history, government, economics, geography and the sciences—the thought subjects with which language must function in community experiences. So long as this false separation continues, I doubt whether any added amount of time would make such improvement in the results of language instruction. What is needed seems to be a fundamental change in the whole plan of operation.

Some recollections of the language experience in the childhood of each of us may be illuminating. It is not primarily by direct drill in language use that little children gain their vocabulary, their sentences, or their later connected discussions. Rather, they observe and identify new objects and occurrences, and acquire words, sentences, paragraphs by means of which to convey their own mental reactions. The yearling's appealing "Go! Go!" when he desires an automobile ride, slowly but surely develops into the three-year old's "Please take me for a ride." Later the five-year-old elaborates his wish into a description of the place and the purposes for which he would go on a trip. Still later, the eight- or nine-year-old writes a description of the trip taken. Following all this elementary but fundamental language development, we set up our courses in languages by which we rationalize previously acquired practices, and attempt to improve them. These courses of formal instruction last through elementary school, high school, and part of college. During these courses improvement is made in language which was begun in the use of a natural

method in the early years. Why not continue language development in its organic and natural association with the fields of essential thought? Why not ask the teachers of thought subjects to increase their attention to language and reduce correspondingly the time scheduled for language? Such a plan has the support of logic, of early experience, and of educational psychology.

The ready reply is that teachers of science, history, etc., do not use or teach the best language forms, hence would not be good language teachers. This is said with some foundation, even though the teachers of these subjects themselves are part of the product of the existing plan of language instruction. That is, the teachers of thought subjects help to prove that existing language instruction is not as effective as desired. However it must be clear that if only those who teach language are users of good language, not much of a case can be made for it. In such an interpretation, the conclusion is that teachers teach language in order to produce more teachers of language.

This proposed change I have suggested would not take care of modern foreign languages in high schools. Let us again raise the question of why we teach French, German, Spanish and Italian to so many pupils in modern secondary schools. Some one replies: "So that pupils may speak the language when in a foreign country." However, but few pupils reach France or Germany. Those who go, are there but a few weeks at most. When there, these few rarely speak the language sufficiently to get about except by an accompanying graphic use of their hands. The usual procedure for those who travel is to use English, and to be guided about by natives who have found it economically useful to learn English in order that they may be paid to guide English speaking travellers. Such a vocational use of French or German in America is not yet open to American boys and girls, since our few foreign visitors do not require guides who speak their native language. Ambassadors, members of commissions, and other advanced types of travellers need foreign languages, and must fit themselves for these needs. It is absurd to require that such languages shall be studied by hundreds of thousands of children, most of whom will live relatively local lives. The very few adults who will have such needs, can, and usually do, meet those needs when occasions present them.

Another reason given for teaching so much modern foreign

language is that pupils may read the literature, history and science of foreign countries. In many cases the languages might possibly render this service, though studies have shown that there are few indeed who continue this use of a foreign language. Still another reason given is that the foreign language may make a contribution to a better English usage. This has not been proved. Our foreign languages are too often taught by persons who use very faulty English, and we cannot expect and do not get help, but harm, to English from that source. Why not face these questions honestly, and make over the high school course in terms of the kinds of lives the pupils will live? Do we have the insight and the courage to set up a new plan by which we might, perhaps save much time, and improve the results of the work done? Would teachers of English and those of the thought subjects be willing to experiment with a plan in which all would teach thought subjects, and all teach the English language, with a separate course or two in whatever parts of English are found by experiment to be best done in separate courses? Or are we so devoted to our present professional associations and commitments that we cannot see the possibilities of such a new way of doing things? Shall we continue our inefficient plan because we have got into the habit of using it?

II. *The program of studies of the high school, like its predecessor in the college, has grown up as a series of separate subject interests.*

Most high school programs seem to indicate either that we believe in dissociated subjects, or that we are helpless in finding and using inter-relations. It is not an integrated program that we offer to the high school pupil. Out of the confusing display of subjects representative of modern human knowledge, the pupil is supposed to accumulate sixteen units of credit, of which the language requirement is the largest and as yet the most coherent part. Usually the pupil may choose different lines of work, or in many schools he may choose the individual subjects year by year. If the separate choices are to result in an organized education for him he or some older guide should coordinate these separate studies in some adequately unifying way. Does this mean that the best we can do is to teach these divisions of knowledge, leaving it entirely to later chance occasions to bring together the related elements of our subjects. In our instruction, we are providing the pupil fairly well with well-constructed building materials, distributed throughout his

intellectual premises. But we do not give him any coordinating blue prints to help him construct his personal intellectual home. Indeed, we know too little as yet, about individual needs and thus devote our efforts largely to presenting the materials from which we blindly hope that individual needs may be met. We can hardly claim that modern secondary education teaches its subjects with a dominating interest in the pupil's place in his community.

My suggestion for improvement of this situation is not adequate, since it again relates to subject matter rather than to qualities and needs of individual pupils. If subject matter integration can be improved, possibly that will be a step toward finding out more about the reorganization needed to fit pupils for special capacities and probably special relations to the society of which he is now a part and in which he may later become a large part.

There are certain guides for use in developing an integrated high school program. The things people must do, must think about, and act upon, out of school, are primarily the legitimate concerns of school work. This means that we must recognize the natural world of the sciences, and the geographic, civic, historic, social and economic concerns of men, as composing the chief thought materials of education. Language, music, art, etc., by means of which to express ideas and ideals are closely related, and are essential in their relation to the centralizing core of thought materials.

The secondary school will not provide an integrated education for its pupils until it organizes its program of studies and its activities more closely about the fundamentals of modern living. Prominent in these fundamentals are the natural and social sciences. Even if we wish, we cannot dissociate ourselves from these. Our lives are built upon knowledge and use of the natural world, and upon human relationships. For decades, we have heard and have assented to this thesis. However, we have shown remarkable inability to do in practice as our own theories indicated that we plan to do. Practice always lags behind theory but there is a wide discrepancy between what we say, and what the schools do, though progress has been made in what the schools accomplish. The vested interests of education do not longer worry overmuch about our assertions of what should be done, since they have learned that most educators "take it out in talk" and rarely lead the way in

action. Even our experimental schools devote more time to lecturing about progressive advances, than to the far more laborious but more necessary task of providing by tested experiments just what can be done. Except in the fields of politics and religion, the leaders in human betterment have not been public speakers primarily, but experimental workers. It is said that a noted and eloquent lecturer, in order to keep two engagements in one day, used an airplane and two high powered automobiles, and in both addresses spoke on "Civilization's Dangers from Scientific Inventions." Such is the inconsistency between lecturing and practice.

III. *My third major question is: Are high schools really used as a means of growth in those qualities, which we loosely call citizenship?*

I believe they are nearly always so used to some extent; however, the citizenship results are not of the best, because those in charge do not realize the extent to which the high school is a factor in determining the future human relationships of its pupils. Wherever hundreds of young people live and work together for four or six years, there we have vital training in some kind of citizenship. If the management is excessively negligent or excessively arbitrary and dominating, the resulting citizenship is likely to be bad. If the management is genuinely cooperative there are opportunities for development of the best types of citizenship. We must dismiss the common notion that it is our privilege to choose whether these modern high schools will be used for social and civic purposes. All are being so used. It is, however, our privilege to choose whether these modern and social and civic centers shall drift back and forth in the ebb and flow of their own driving forces, or be purposefully guided toward chosen types of social responsibility and action.

The high school community is real, not improvised. It has its aesthetic, intellectual and governmental needs. If these needs are met arbitrarily by an administrative head, the school citizens get little growth therefrom. If all cooperate in meeting these needs, there is more growth in desired directions. School cooperation in management must be genuine, not make believe, else distrust follows. Cooperative decisions are safe when pupils know they really are charged with responsibility for what their school does. Their leader is like a mayor who must sometimes

make and enforce decisions. But pupils and their pupil committees are like citizens and groups who may always be heard by their appointed chiefs when careful thinking has led them to conclusions.

A cooperatively managed school group requires superior teaching. It is far easier, takes less brains and efforts, to manage a group arbitrarily, and the group may be more orderly in the older meaning of orderly. A civic and cooperative school group makes more noise because more is occurring. But such is more nearly normal, more nearly like the kind of human groups into which pupils will later go. A quiet school group may be essentially futile. The noise made by real work is natural, not harmful. Mere noise dissociated from work no good teacher will tolerate.

IV. *My fourth question relates to the individual attitudes which cause different persons to react as they do.*

It now seems possible that we may soon recognize individual attitudes as the most important of all educational objectives. Attitudes guide conduct, and good conduct is second to nothing else in human relations. Secondary school ages include a major part of the period when personal and social ideals are being established. It is argued by some that attitudes are acquired by indirect teaching for attitudes. By others it is asserted that attitudes are subject to instruction as are other objectives. Both these methods may be effective. However, experimental work has proved that instruction can affect attitudes. It is a matter of common knowledge that most persons are guided to some extent by superstition and magic. Tests that have been given have disclosed no individual entirely free from some such beliefs. Organized units of instruction including factual discussions have been used experimentally, and have produced desirable changes on the part of high school pupils. How long these changed attitudes may persist, or how extensive such changes may become, are not known. It is known, however, that the curriculum has no end of units of instruction, easily available for reorganization of factual instruction regarding controlling attitudes. The social studies, especially geography and history, also literature and the sciences, need have no new units added to them in order to accomplish effective teaching regarding attitudes. Experimental work already accomplished presents the plan for needed reorganization and for the ac-

companying instruction. I believe curriculum makers, text-book writers, and other leaders in improved instruction will accept and extend what is now known about development of needed attitudes, and that the next decade will see much improvement in this type of teaching. The appalling need for this change may be emphasized by reference to Professor Lynn Thorndike's statement resulting from his life-long study of such questions. In his closing chapter of his monograph, he says that most of the human race most of the time is guided by magic. Why can't the modern secondary school do more than it is doing to improve people's controlling attitudes?

AMPLIFYING THE CHEMICAL EQUATION

By Eugene W. Blank

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The chemical equation is a shorthand stoichimetrical expression of a chemical reaction. With the aid of a few conventional symbols it can be made to express much added information in regard to the reaction taking place. Thus it is usual to designate a precipitated compound by underlining or by use of a vertical arrow pointing downward. Gases are represented by vertical arrows pointing upwards. Heat is usually designated by the Greek letter Δ (delta). Equations (1) and (2) illustrate these points respectively.

$$AgNO_3 + HCl \rightarrow \underline{AgCl}\ (\text{or } AgCl \downarrow) + HNO_3 \qquad (1)$$

$$2HgO + \Delta \rightarrow 2Hg + O_2 \uparrow . \qquad (2)$$

Few authorities employ symbols other than those described though McAlpine and Soule,[1] employ a straight line and an upturned bracket or combination of both beneath a compound in one of their tables to designate respectively, a soluble, an insoluble compound and a compound soluble in excess of the precipitating agent.

The writer designates insolubility and gas evolution by means of vertical arrows. Beneath the precipitated compound, to the right, a subscript letter or combination of two letters designates the color of the precipitated material. To the left is placed the

[1] McAlpine and Soule, "Qualitative chemical analysis," based upon the text by Prescott and Johnson, D. Van Nostrand Co., Inc., New York City, 1933, p. 4.

formula of a solvent. If the solvent must be heated to dissolve the precipitate it is preceded by Δ (delta). A straight line beneath the formula of the precipitate indicates that the precipitate is soluble in excess of the precipitating agent. Equations (3) to (5) illustrate the use of these added symbols which are of especial value in presenting shorthand expressions of the steps in analytical separations.

$$NiCl_2+2KOH \rightarrow \underset{HCl\quad Gn}{Ni(OH)_2} \downarrow +2KCl \tag{3}$$

$$ZnCl_2+2KOH \rightarrow \underset{HCl\quad W}{\underline{Zn(OH)_2}} \downarrow +2KCl \tag{4}$$

$$Pb(NO_3)_2+2HCl \rightarrow \underset{\Delta H_2O\quad W}{PbCl_2} \downarrow +2HNO_3 \tag{5}$$

AN APPROXIMATE SOLUTION OF A SYSTEM OF QUADRATIC EQUATIONS

By Cecil B. Read
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Among the better students of a class there is frequently a feeling that the treatment of simultaneous quadratic equations stops before the subject is satisfactorily handled. Certain types are discussed in detail, mention is made of certain special devices which will handle particular systems, the student is urged to use his ingenuity in developing other devices; nevertheless some good student will discover a system which he cannot solve. Some texts omit any mention of the fact that the solution of a general system cannot be accomplished without the solution of a cubic equation. At least one text makes the erroneous statement that the solution of a general system requires the solution of a quartic. Verification of the statement that any system consisting of two quadratic equations in two unknowns may be reduced to that of solving a certain auxiliary cubic equation involving only one unknown may be found in Wilczynski's College Algebra, Chapter XIII. (Of course if a cubic can be solved one has the essential part of the solution of a quartic.)

It is very easy to find two equations which do not yield to any of the methods usually discussed. For example, we may have

$$x^2+y = 7$$
$$x + y^2 = 11$$

for which (2, 3) is an obvious solution, yet the complete set of solutions is difficult to find; moreover, it is not easy to find a method which will give the particular solution mentioned. It is of course possible to solve graphically, but if the solution happens to be irrational, the labor required to construct successive graphs for an accurate approximation is excessive.

If the student is familiar with the solution of the cubic any such system is completely solvable; likewise if he is familiar with Newton's or Horner's method, the real solutions may be obtained with any desired degree of accuracy. The following method requires no knowledge beyond that available when the subject is first encountered, yet it will yield any desired degree of accuracy in approximating any real solution. The method is not original with the writer but he has failed to find it mentioned in any elementary text. It can best be illustrated by application to a system similar to the one mentioned, but with an irrational solution.

Given the system

$$x^2+y = 5$$
$$x + y^2 = 6.$$

Even a crude graphical solution gives approximate values: $(-1\frac{1}{2}, 3)$; $(-3, -3)$; $(2\frac{1}{2}, -2)$; and $(2, 2)$. If desired, greater accuracy can readily be obtained from a simple graph. Let us concentrate on the approximate solution (2, 2). Suppose the actual solution is $(2+a, 2+b)$ where a and b are corrections. Since these are small quantities, terms involving them which are of second or higher degree may be neglected. If we substitute these values in the original equations and neglect second degree terms, we have the linear system

$$4a + b = -1$$
$$a + 4b = 0.$$

The solution of this system, computing results to two decimal places, is $a = -.27$, $b = .07$. Accordingly, as a second approximation, we have the solution (1.73, 2.07).

If greater accuracy is desired, the process is repeated, using these values for x and y and assuming the actual value to be $(1.73+a_1, 2.07+b_1)$ where a_1 and b_1 are supplemental corrections. Proceeding as before, we obtain

$$3.46a_1 + \quad b_1 = -.0629$$
$$a_1 + 4.14b_1 = -.0149$$

from which $a_1 = -.0184$ and $b_1 = .0009$ (neglecting figures beyond the fourth decimal place) consequently as a third approximation we have (1.7116, 2.0709).

In similar fashion we can determine $a_2 = -.000132$ and $b_2 = -.000023$ giving as a fourth approximation (1.711468, 2.070877). It is apparent that we can continue the process indefinitely, just as we may stop at any point desired. As a check we may substitute in the original system the values obtained in the fourth approximation. Values obtained by use of a seven place table of logarithms are

$$x^2 + y = 4.999999$$
$$x + y^2 = 6.000000.$$

Obviously the method can be applied to any desired real root. In any physical application a good guess will usually supply the first approximation, eliminating the need for a graph. The method fails to yield complex roots, but it will be noted that it can be applied without any change to equations of any degree in any number of unknowns.

GROWTH RATE OF YOUNG CHICKS INFLUENCED BY TEMPERATURE

Farmers may some day control the temperatures of their incubators and brooders much more carefully than they now do. The results of a series of researches by Drs. M. Kleiber and J. E. Dougherty of the college of agriculture of the University of California seem to call for this application of science to poultry raising.

They have found that the growth rate of chicks increases as the temperature at which the chicks are kept is decreased, down to about 70 degrees Fahrenheit. However, they have also found that the amount of energy obtained from a given amount of food increases as the room temperature is raised up to about 88 degrees Fahrenheit, then decreases as the room is made still warmer.

At low temperatures the chick eats more, in order to keep its body temperature up. But the efficiency at which this food is used is much lower than at higher temperatures. At lower temperatures than those at which the experiments were carried out, so much food would be required just to keep up the body temperature that the animal would be unable to eat enough. It would starve to death, even though it were eating as much as its digestive organs could take care of.

APPLICATIONS USED FOR IMPROVING TESTS AND WIDENING THE SCOPE OF GENERAL SCIENCE

By Robert B. Colvin
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The purpose of this paper is to describe the means by which improvement has been achieved through a wider and more frequent use of the applications of the scientific principles developed in topics of study. Two undeveloped possibilities in the use of these applications will be suggested. The author has found by questioning teachers that many use less than half, including the simpler ones, of those listed below. Some teachers will recognize many as common to their teaching material and practice, but it is probable that of the applications here listed, many teachers will find a few that are novel and acceptable—which is one intent of this paper. The list includes applications of varying degrees of difficulty for eighth and ninth grade students. Another factor to be considered is tha all teachers do not have use of the more recent texts, with the result that student and teacher tend to think only in terms of the applications suggested in the text.

Two Ways to Extend the Use of Applications

(1) The improvement of tests with emphasis removed from factual text matter is an undeveloped possibility in the use of applications. Testing of certain facts will continue to be desirable but a surer measure of a pupil's growth can be determined by testing his ability to *apply* a previously learned principle to a *new* situation. To this end a teacher with a large number of applications to draw upon may purposely hold some in reserve from class discussion. The undiscussed applications then arranged in the form of a problem, or a multiple-choice question, become a test to determine a pupil's ability to recognize the old principle in a new situation. For example, assuming that the application (in air pressure) of the need of two holes in a can of evaporated milk has been reserved from class discussion it could be developed as a test on the principle of air pressure in two ways: first, as a problem to be explained—

It is found that to have milk flow freely from a tin can, two holes must be punched on opposite sides of the top. When the can is tipped the milk flows freely from the lower hole. If the finger be placed over the upper open-

ing the flow stops. State the principle you have studied which is acting here and explain its functioning in this case. (Teacher could illustrate with an actual can.)

Secondly, it could be framed as a multiple-choice question—

A can must have two holes on opposite sides of the top in order that milk may flow out, because: (a) with one hole the air pressure is greater inside than outside the can; (b) the milk is so thick that it can not flow readily; (c) with one hole a low air pressure area tends to form behind the milk in the can; (d) the air pressure is the same inside and outside the can when only one hole is made.

(2) Increasing the scope of the more capable student's scientific knowledge is a possibility in the undiscussed applications. Some of the more difficult applications listed below suitably prepared and presented to such students as matter worthy of their investigation have been found to serve such a purpose admirably, more so than unattached or insignificant topics to "look up." For example, an investigation into the nature and development of *streamlining* as an application growing out of the topic of air pressure was developed from current periodicals by one of the author's pupils into an illustrated study of exceptional merit. His study of this application of the principle of air pressure went far beyond the point considered in the class as a whole. As suggested in (1) the teacher can sometimes reserve from class discussion some of the applications of wider scope and use them entirely for such extra study by the more capable students.

Several of the listed applications have been contributed by students during class discussion, some by other teachers and others have been found in advertisements appearing in periodicals as suggested in a previous paper.[1] The following applications of scientific principles are listed as material for (1) developing variety and for increasing the means of testing the students' growth and (2) for suggesting new and interesting fields of investigation.

Atmospheric Air Pressure

Two openings in top of evaporated milk cans and ink bottles; gurgling of liquids from bottles; hissing sound upon opening certain tin cans of food; vacuum cleaners; streamlining; rushing of paper and dust after rapidly moving trains; poultry fountains; suction discs on small window display shelves, ash catchers, glare shields for automobiles, tennis shoes, some automobile tires, drain cleaners; popping of light bulbs when broken; functioning of lungs; floating of balloons; fountain pens; medicine drop-

[1] Colvin, R. B., *Advertisements as a Teaching Device in General Science*, School Science and Mathematics, January 1934, Vol. XXXIV, No. 1, pp. 79–83.

pers; water lift pump; soda "straw"; high altitude balloons starting ascent with bag partially inflated; difficulty in breathing at high altitudes; sensation in ears and throat during rapid ascent; inability of fountain pen to retain ink at high altitudes; limit of ascent for planes regardless of motor power; difficulty of heating water at high altitudes; houses blown apart during tornado if all doors and windows are closed.

Compressed Air

Street car and electric train whistles; some door checks; tree and paint sprayers; device for control of heat and ventilators in some school rooms; tires; footballs; pneumatic drills for rock and pavements; sand blasts; caissons for building tunnels; force pumps on fire engines; delivery tubes between offices; brakes on trains and some busses; pressure on ear drums when riding rapidly through tunnels; some air rifles; "bends" in caisson workers.

Sound

Better audibility by placing hand behind ear; feeling vibrations in object, as a book, held in hand during organ or orchestra concert; better carrying of voice by use of megaphone; unfurnished rooms have "hollow" sound; early broadcasting studios hung heavy drapes on walls; walls in modern buildings made sound proof by filling with loose materials; formation of echoes; clear transmission of voice across lakes; soundbox with needle produces louder tone from victrola record than needle held in fingers alone; watch heard more clearly when placed on hard surface than when held in hand; band "shells" used for outdoor concerts; wheels of approaching train heard clicking in rails before train is seen; Indians heard approaching horses by putting ear to ground; submarine officers detect approaching or passing ships above them; sounds from telephone receivers; sudden dives by airplane as aid for deaf people; determining ocean depth by echo from bottom.

Fire—Oxidation

Dust explosions occur readily in flour mills, grain elevators and other places producing fine dust; mown grass left in pile becomes hot in center; damp hay in barns start fires; wet paper and wood will not burn; foresters clear away wide path through forests; painting of wood and iron preserves it; matches tipped with phosphorous and sulphur compounds; black smoke from chimney sometimes indicates poor draft; "soot" deposited by yellow flame on a cold porcelain dish; blue gas flame causes "soot" to disappear from dish; fires sometimes start when one uses gasoline for cleaning; automobile engines should be shut off while tank receives gasoline.

Water and Rain

"Frosting" of cooling unit of automatic refrigerators; dishes removed from refrigerator become covered with mist; "frosting" of metal containers of ice cream carried from truck to store; formation of mist on cold water faucet on warm day; mist from mouth outdoors on cold morning; mist on kitchen windows while preparing meal during winter; mist on windows and tile of bathroom while taking warm shower; mist on eyeglasses upon entering warm room from cold air; "sweating" of cold water pipes in basement during summer but not during winter; cooling effect of the refrigerant in automatic refrigerators; cooling effect of rubbing fever patients with alcohol; comparison of rain formation with distillation process.

Water Pressure

Deep sea fish when brought to surface by scientists, as Beebe, frequently "explode"; experienced sponge divers of south seas frequently die as a result of seeking richer supply at greater depths; objects "weigh less" when weighed in water than in air; boats weighing thousands of tons float on water; people float readily on Great Salt Lake; cementing of sedimentary rock material; ordinary diving hurts some people's ears.

Convection Currents (Heat)

Smoke from smouldering stick, held in front of fire place, swirls into fire place; smoke from cigarette swirling under and up through shade of lighted "bridge" lamp; ceiling of room always warmer than floor or vice versa; firemen, being overcome in burning building, drop close to floor to breathe; coldest section of refrigerator at bottom shelf; early balloons filled with hot air; top portion of automobile radiator becomes warmer than base—conversely, bottom part freezes first in winter.

Insulation

Storing of ice cakes in sawdust; protective effect of snow to winter wheat; wrapping shrubs with straw and leaves in fall; vacuum in wall of thermos bottle; filling space in double wall of some refrigerators with sawdust, cut cork, etc.; coating furnaces with mixture of plaster and asbestos; covering steam pipes with corrugated insulators; warmth of wool blankets and clothing; filling walls of houses with loose fibrous material; food continues to cook in fireless cooker without flame; wooden handles on metal objects which are subject to heat; Eskimo dogs bury themselves under snow to sleep while resting; melting of snow faster from roof on one house than from adjoining house indicates poor insulation and loss of heat.

Absorption and Reflection of Heat

Window sill warmed by sun's rays while glass through which sun passes remains cool; dirigibles painted light silvery color; white clothes worn in tropical and desert countries; some railroad cars on western lines have light colored roofs; soil heats faster by sun than nearby lake; aluminum kettles heat faster if bottoms are allowed to become and remain black; thermos bottles coated with a silver colored material; aluminum kettles remain hot longer than dark colored kettles; lake water retains heat longer at night than nearby soil; orchards safer from frost when near lake shore; certain refrigerators have several silver colored partitions within double wall space; Byrd's hut at his solitary observation post constructed with several silver colored partitions within the walls.

Expansion and Contraction

Automobile radiators lose much water on long, hot trips; telephone wires tend to sag between poles during summer; metal tops of glass jars may be loosened by heating the top; pistons of automobile cylinders sometimes "stick" in cylinders when engine becomes overheated; movements of mercury in thermometer; train rails have space left between ends of rails when laid in winter; large steel bridges are not bolted firmly to piers but rest on well greased rollers; cables of suspension bridges not fixed firmly to tops of towers but rest on rollers; steel tires placed on wooden wagon wheels and locomotive wheels while tire is hot; thermostats to respond to heat changes.

CONCERNING THE DERIVATIVE OF A FUNCTION

By D. H. Richert
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Can a function $f(x)$ have a derivative $f'(x)$ for all values of x when $f'(x)$ itself is not continuous? Geometrically considered, can a curve have a tangent at every point, if the direction of the tangent does not vary continuously? We wish to show that this question can be answered in the affirmative.

Consider the function

$$f(x)=x^2 \sin (1/x); \tag{1}$$

and let $f(x)=0$, when $x=0$. Then $f(x)$ is continuous for all values of x. If $(x)\neq 0$, then

$$f'(x)=2x \sin (1/x)-\cos (1/x); \tag{2}$$

while

$$f'(0)=\lim_{\Delta x\to 0}\left[\frac{(\Delta x)^2 \sin (1/\Delta x)}{\Delta x}\right]=0. \tag{3}$$

Hence $f'(x)$ exists for all values of x. But $f'(x)$ is discontinuous for $x=0$; for $2x \sin (1/x)\to 0$ as $x\to 0$, and $\cos (1/x)$ oscillates between -1 and 1, so that $f'(x)$ oscillates between the same limits.

We recall that we have supposed that $f(0)=0$. Then equation (3) is derived as follows:

$$f(x)=x^2 \sin (1/x),$$

$$f'(x)=\lim_{\Delta x\to 0}\left[\frac{f(x+\Delta x)-f(x)}{\Delta x}\right].$$

$$f'(0)=\lim_{\Delta x\to 0}\left[\frac{f(0+\Delta x)-f(0)}{\Delta x}\right]$$

$$=\lim_{\Delta x\to 0}\left[\frac{f(\Delta x)}{\Delta x}\right], \text{ since } f(0)=0,$$

$$\therefore\ f'(0)=\lim_{\Delta x\to 0}\left[\frac{(\Delta x)^2 \sin (1/\Delta x)}{\Delta x}\right]=0.$$

That this limit is zero can be seen from the fact that the factor $\sin (1/x)$ is never numerically greater than 1.

EUCLIDEAN CONSTRUCTION FOR IMAGINARY ROOTS OF THE QUADRATIC EQUATION

By J. Shaylor Woodruff
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The mention of a Euclidean construction and imaginary numbers in the same title may seem inconsistent. The extension of one of Euclid's constructions to include complex solutions may seem somewhat imaginary. So let us proceed with this thought of J. W. L. Glaisher's in mind, "I am sure that no subject loses more than mathematics by any attempt to dissociate it from its history."

In reading the work of the Greek Mathematicians on the problem of the application of areas, we have unfolded before us a geometrical algebra. It is an algebra in which the conception of negative and imaginary numbers plays no part and which is cumbersome to us used to our modern symbolism.

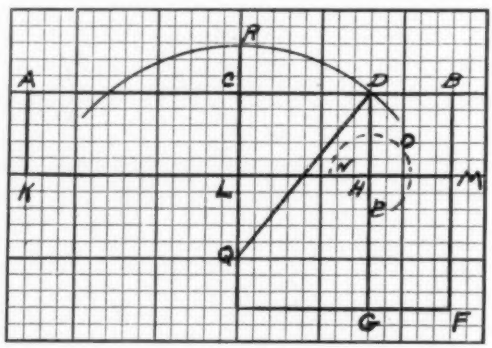

Fig. 1

Nevertheless, it is an algebra complete in its development for numbers known at that time. The method of this algebra leads up to the geometrical solution of the quadratic equation.[1] The problem in its general form is: To apply to a given straight line a rectangle (or, a parallelogram) equal to a given rectilineal figure, and (1) exceeding or (2) falling short by a square figure, (or, in the more general case, by a parallelogram similar to a

[1] Heath, Sir Thomas, *A History of Greek Mathematics*, Volume I. Oxford, Clarendon Press, 1921, p. 150.

given parallelogram).[2] In the second case, i.e., falling short by a given square figure, the solution results in the construction of Fig. 1. In Fig. 1, if the given straight line is $AB=a$ the side of the given square is $CQ=\sqrt{b}$ (b must not be greater than $(\frac{1}{2}a)^2$, otherwise the solution is impossible)[a], then the determination of the segment $BD=x$ is a solution of $x^2-ax+b=0$.

The method most often employed in our modern algebra for the graphical solution of the quadratic equation involves the construction of the parabola. As the parabola enables us to find the roots, when real, of any quadratic equation by suitable movement of the axes, there seemed some warrant for the conclusion that an intimately related curve would perform a similar function for imaginary roots and make the graphical representation complete. Such a curve with several illustrations is found in Hamilton and Kettle *Graphs and Imaginaries*[3] and in a lecture *Graphical Computation for High School Students and Teachers* by M. J. Rabb.[4] These authors have used the name "shadow curve." Indeed this term seems aptly chosen for the characteristics of the shadow curve bring to mind

"I have a little shadow that goes in and out with me,

. . . .

He is very, very like me from the heels up to the head

. . . .

For he sometimes shoots up taller like an India-rubber ball
And he sometimes gets so little that there is none of him at all."[5]

Although the parabola and the shadow parabola readily give the solutions, the circle has advantages in that it is more easily and accurately drawn and we can limit ourselves to the ruler and compasses. Thus we have the satisfaction of developing a construction within the restrictions of Plato's dictum—use only the ruler and compasses. Accepting this dictum and introducing a shadow circle I present a method by which imaginary roots of the quadratic equation can be found graphically as

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[2] Simson, Robert, *The Elements of Euclid*. Philadelphia, Johnson and Warner, 1811. Book VI, Propositions 28 and 29, pp. 186–188 and Notes, pp. 334–338.

[a] This is the condition for real roots in the discriminant of the quadratic $x^2-ax+b=0$.

[3] Hamilton, J. G. and Kettle, F., *Graphs and Imaginaries*. London, Edward Arnold, 1904.

[4] Babb, M. J., "Graphical Computation for High School Students and Teachers." *Fifteenth Annual Schoolmen's Week Proceedings*. University of Pennsylvania, 1928.

[5] Stevenson, Robert L., *My Shadow*.

easily and as accurately as real roots. The construction for imaginary roots will be seen to follow closely in the steps of that for real roots, justified too with an almost identical proof.

Let us continue inductively. Look at the construction of Fig. 1 with modern eyes, accustomed to negatives and imaginaries and coordinate axes. The analogy is shown in Fig. 2. Furthermore, although $\sqrt{b}$ is readily obtained by graphical con-

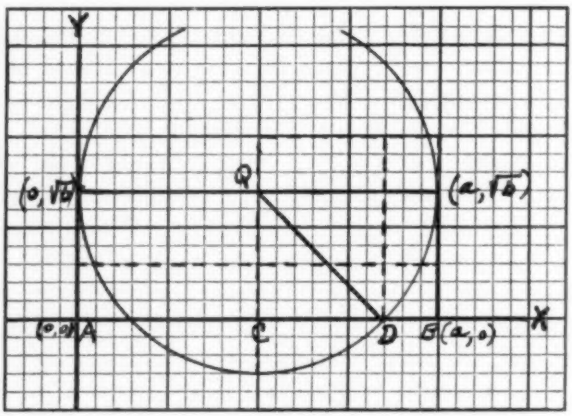

FIG. 2

struction, we factor b into $1 \cdot b$, and then if $x^2 - ax + b = 0$ has real coefficients and real roots, the roots can be constructed with ruler and compasses as follows: Draw a circle having as a diameter the line PR joining the points $P = (0, 1)$ and $R = (a, b)$ in Fig. 3. Then the abscissas of the points of intersection of the circle with the x-axis are the roots[6]—which may be read

[6] This method is given in: Dickson, L. E., *First Course in the Theory of Equations*. New York, John Wiley and Sons, Inc., 1922, p. 29; and Hardy, G. H., *A Course of Pure Mathematics*. Cambridge, University Press, 1928, p. 21. The problem of the quadratic equation has its origin in the discovery by the Pythagoreans of the problem of the application of an area which resulted in geometrical constructions (Heath, Sir Thomas, *A History of Greek Mathematics*, Volume I. Oxford, Clarendon Press, 1921, p. 150). The development of its solution is analogous to that of algebra as the limitations of symbolism and restrictions in signs are removed (Smith, D. E., *History of Mathematics*, Volume II, New York, Ginn and Company, 1925, p. 378). It follows that we have various solutions both algebraic and geometrical. In addition to those noted above, I mention: the construction, associated with Plato, for the duplication of the cube (Gow, James, *A Short History of Greek Mathematics*. Cambridge, University Press, 1884, pp. 180–181); the construction by Captain Lill (Lill, M. E., "Resolution Graphique," *Nouvelles Annalse de Mathematiques*, Volume VI, Series 2, 1867, p. 359); the construction by Dr. Klein (Klein, Felix L. (Beman, W. W. and Smith, D. E. trans.), *Famous Problems of Elementary Geometry*. Boston, Ginn and Company, 1897, p. 34); the construction by John Wallis (Coolidge, Julian Lowell, *The Geometry of the Complex Domain*. Oxford, The Clarendon Press, 1924, pp. 14–15); and the construction given by R. W Dull (Dull, Raymond W., *Mathematics for Engineers*. New York, McGraw-Hill Book Company, Inc., 1926, p. 123).

$AC \pm CD$. When the circle cuts the x-axis in two distinct points, unequal positive roots are obtained. When the circle is tangent to the x-axis, equal positive roots result. When the circle does not cut the x-axis, or when R coincides with P, the roots are imaginary. For the first two cases, the construction is adequate, but not for the latter in which case the roots are imaginary.

The construction for $x^2+ax+b=0$ and negative roots is obtained by laying "a" to the left of the origin rather than to the right. For $x^2 \pm ax-b=0$, draw the circle having as its diameter the line joining $P=(0, 1)$ and $R=(\mp a, -b)$. In these last two cases the roots are always real and in the construction the circle always cuts AB. Hence our problem reduces to a consideration of $x^2 \pm ax+b=0$.

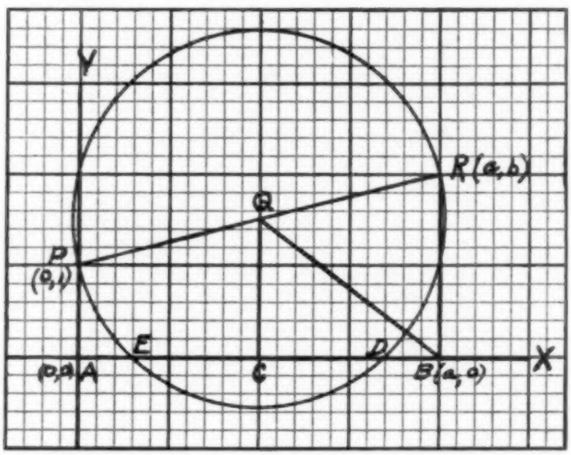

FIG. 3

With Fig. 3 in mind and $x^2-ax+b=0$ as our standard equation (a and b positive), keeping "a" constant and giving "b" continually increasing values, it will be noted

(1) that the circle recedes from AB;
(2) that the roots are:

$AC \pm$ (*a* continually decreasing quantity), then
$AC \pm 0$, when the circle is tangent to AB, next

$AC \pm i \cdot$ (a continually increasing quantity). It will be readily perceived that the shadow circle which is to give us the roots as intercepts of the x-axis cannot be the mere reflexion of the

other, but one which will accommodate itself to its inseparable but retiring companion. This accommodation is accomplished by inversion. Thus it is found for such an equation as $x^2-ax+b=0$, Fig. 4: (1) that the radius, r, of the circle is equal to $\frac{1}{2}\sqrt{a^2+(b-1)^2}$; (2) that the center of the shadow

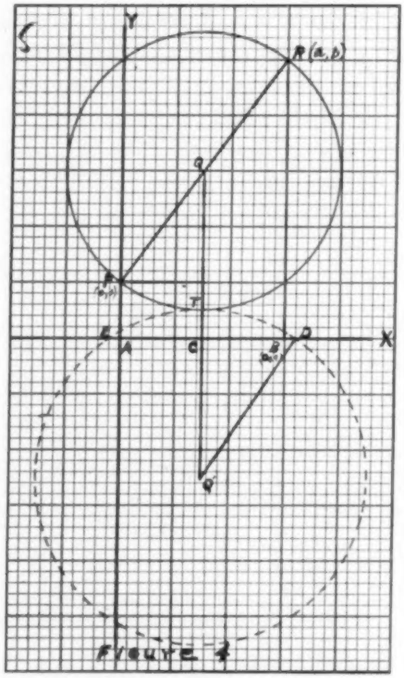

FIG. 4

circle must be taken at a distance of r below AB; and (3) that the radius of the shadow circle is $\frac{1}{2}(b+1)$. As in the previous solution, if the circle cuts the x-axis in D and E we have real roots which may be read $AC \pm CD$. If the circle does not cut the x-axis, the shadow circle does, and we have intercepts which may be read $AC \pm CD$. These intercepts are found to be roots of $x^2-ax+a^2/2-b=0$. Again, the roots of this equation are

$\frac{a}{2} \pm \sqrt{b-\frac{a^2}{4}}$ and of the former equation $\frac{a}{2} \pm \sqrt{\frac{a^2}{4}-b}$ or

$\frac{a}{2} \pm i\sqrt{b-\frac{a^2}{4}}$. Eureka! the key to the solution. From the in-

tersection of the shadow circle with the x-axis, we read $AC \pm CD$, insert "i" as a multiple of the second term, CD, and obtain $AC \pm i \cdot CD$, and have the imaginary roots of $x^2 - ax + b = 0$. In every case for which the roots are imaginary, the shadow circle meets the needs of its comrade, first, by assuming for its radius a length equal to the radius of the companion plus the distance which the tangential point of the circle moves away from the x-axis, and, second, by cutting the x-axis in points D and E as the circle retires, thus giving the necessary multiple of "i" in the roots demanded by the increase in the constant term "b".

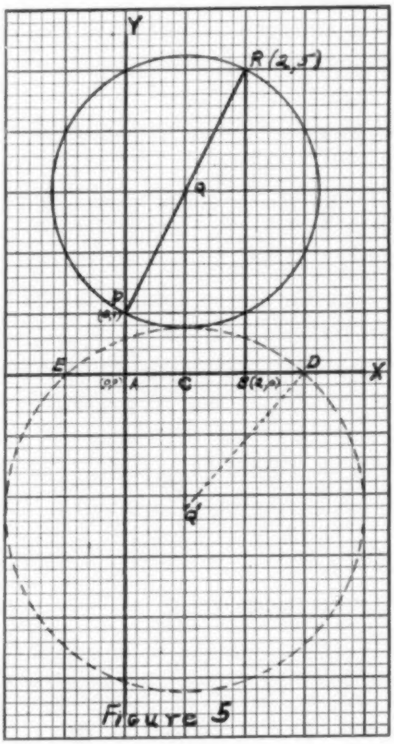

FIG. 5

As an illustration of this method, let us solve the equation $x^2 - 2x + 5 = 0$. Draw a circle having as a diameter the line joining the points $P = (0, 1)$ and $R = (2, 5)$ as in Fig. 5. This circle does not cut the x-axis so its roots are imaginary. Construct a shadow circle with center at the point $Q' = (1, -\sqrt{5})$, ($\sqrt{5}$ being the radius of the companion circle), and radius equal to

$3(=\frac{1}{2}[b+1])$. From the intersections with the x-axis the roots are $AC \pm i \cdot CD$. Now from the figure $AC=1$ and $CD=2$. Substituting these values, we obtain $1 \pm 2i$, the imaginary roots of $x^2-2x+5=0$.

In general, if the equation $x^2-ax+b=0$ has real coefficients, the roots, real or imaginary, can be constructed with the ruler and compasses as follows: Draw a circle having as a diameter the line PR joining the points $P=(0, 1)$ and $R=(a, b)$ in Fig. 4. If the circle cuts the x-axis, the abscissas of the points of intersection of the circle with the x-axis are the real roots which are read $AC \pm CD$. If the circle does not cut the x-axis, draw a shadow circle tangent to the companion circle and with its center at a distance equal to the radius of the companion below the x-axis directly under the center of the circle, or symbolically with center at $\left(\frac{a}{2}, -\frac{1}{2}\sqrt{a^2+(b-1)^2}\right)$ and with radius equal to $\frac{1}{2}(b+1)$. The shadow circle cuts the x-axis in points D and E. The abscissas of these points are read $AC \pm CD$, "i" is inserted as a multiple of the second term CD, and the results are $AC \pm i \cdot CD$ which are the imaginary roots.

The proof of the method follows. In the case of real roots, the center of the circle is $\left(\frac{a}{2}, \frac{b+1}{2}\right)$ and the radius QP is $\frac{1}{2}\sqrt{a^2+(b-1)^2}$, Fig. 4. Hence the equation of the circle is

$$\left(x-\frac{a}{2}\right)^2+\left(y-\frac{b+1}{2}\right)^2=\frac{a^2+(b-1)^2}{4}.$$

This equation solved with $y=0$, is found to give the abscissas of the points of intersection as $\frac{a}{2} \pm \sqrt{\frac{a^2}{4}-b}$. In the case of imaginary roots, the center of the shadow circle is $\left(\frac{a}{2}, -\frac{1}{2}\sqrt{a^2+(b-1)^2}\right)$ and the radius $Q'D$ is $\frac{1}{2}(b+1)$. Hence the equation of the shadow circle is

$$\left(x-\frac{a}{2}\right)^2+\left(y+\frac{1}{2}\sqrt{a^2+(b-1)^2}\right)^2=\frac{(b+1)^2}{4}.$$

This equation solved with $y=0$, is found to give the abscissas of the points of intersection as $\frac{a}{2} \pm \sqrt{b-\frac{a^2}{4}}$. These values with "$i$" as a multiple of $\sqrt{b-\frac{a^2}{4}}$ are $\frac{a}{2} \pm \sqrt{\frac{a^2}{4}-b}$ which completes the proof.

We have seen in this construction of the roots of the quadratic equation the use of a circle to give real roots, and the use of an intimately related circle, the shadow circle, to give imaginary roots. The principle is capable of wider application. The graphical determination of the imaginary points of intersection of a straight line and a circle is an immediate consequence of the fore-going. Proceeding on somewhat similar lines with two equal circles, the locus of the imaginary points of intersection is found to be a rectangular hyperbola. We can make use of shadow circles to give the imaginary points of intersection of a tangent drawn to a circle from a point within the circle. Fundamental to all is the inversion and reflexion in the construction of the shadow circle.

NEW HOME FOR WORLD'S FAIR MEDICAL EXHIBITS IS STEP TOWARD AMERICAN MUSEUM OF HYGIENE

A big step toward establishment in this country of a museum of hygiene like the famous German Hygiene Museum in Dresden will be taken when most of the important medical exhibits of the Century of Progress Exposition are moved into a permanent home at the Museum of Science and Industry, Chicago.

The Dresden museum is today the world's only large scale health museum for the general public.

A movement to give America its own museum of hygiene, which should become a dynamic force in teaching health to the people of the country, was started at a meeting of the American Public Health Association several years ago. Such a museum would not infringe on the private physician but would make the layman more capable of cooperating intelligently with the physician and public health worker in guarding his own and his neighbor's health.

It was hoped that the Century of Progress exposition's medical exhibits would form the nucleus of such an independent health museum here. Since this could not be achieved, it was arranged to house most of them in a new medical and health division of the Rosenwald Museum.

With the exception of the group exhibit of the Wellcome Research Institute of London, all the foreign medical and health exhibits will go to the the Rosenwald Museum as well as those from national medical and health organizations in this country, university departments of medicine and hygiene, the Chicago Board of Health and a number of local medical and health organizations.

COMPUTING THE EXACT MASS IN GRAMS OF AN ATOM

By Donald L. Cole
Seneca, Kansas

As a matter of scientific interest to a class in high school chemistry, a method of computing the exact mass in grams of any atom is suggested. The method is simple in itself, but the subsequent discussion should be followed closely in order to gain a good understanding of the fundamentals upon which the calculation will rest.

To go back to our grammar school days, if we were told that forty apples weighed eighty ounces, and that the apples were of equal weight, we could readily find the weight of a single apple. In the final analysis our formula will prove to be of no greater difficulty.

We learn in our high school chemistry that a gram mole of any substance, if gaseous, occupies under standard conditions 22.4 liters. We have also studied Avogadro's hypothesis which says substantially, "equal volumes of all gases under the same conditions of temperature and pressure contain equal numbers of molecules." This means, of course, that 22.4 liters of nitrogen, for example, will have the same number of molecules as 22.4 liters of oxygen, or carbon dioxide, or chlorine under the same conditions of temperature and pressure.

If you stop to think, you will see at once that this number of molecules under these conditions must be a constant. Would it not be interesting to know the numerical value of that constant? A gram mole of hydrogen, 2.016 grams, occupies under standard conditions, 22.4 liters. The number of molecules for this volume is constant, and the value is known. Could we not easily find the weight of one molecule of hydrogen? We know the weight of 22.4 liters and the number of molecules contained therein. It is evident that the weight of one molecule is equal to the weight of all the molecules divided by the number of molecules present. This will give the weight in grams. Since there are two atoms of hydrogen in every molecule, we have but to divide by two to find the weight of one atom.

We have mentioned the fact that there is a constant, and we have shown in the case of gaseous substances how it could be used in determining the weight in grams of both molecules

and atoms, but we have not stated the value of this constant, nor shown its application to elements other than gases. According to Millikan,[1] the Avogadro constant is 6.06×10^{23} molecules per gram mole.

It might be of interest to review briefly the experiment and the procedure by which Millikan worked out this value. It is a known fact that droplets of liquid shot from the nozzle of an atomizer are often charged electrically. Millikan believed that a determination of the charge on a series of oil droplets might lead to some interesting scientific evidence. In accordance with this belief he arranged an apparatus whereby he could create droplets with an atomizer, and then by ejecting these into a chamber in which he had arranged a vertical electric field, he could cause these droplets to rise and fall by varying the strength of the field. By this means he could create a field of sufficient intensity to exactly balance the weight of the drop. The weight of the drop can be determined by the definite relation which exists between weight, diameter, and the rate of fall in air.

The electrical force which balances the weight of the droplet is equal to the product of the charge on the droplet (e) and the intensity of the electric field (E). Since this force equals or balances the weight of the droplet (W) the equation becomes $eE = W$. The quantities E and W are known, so it becomes evident that the charge e born by the droplet can be calculated. Dr. Millikan worked out this value e for a great many trials on droplets of varying mass. He discovered that the charge born by any one droplet is always a multiple of a certain small quantity of charge whose value is 4.77×10^{-10} electro static units, or for our purposes this value is 1.591×10^{-19} coulombs. As Saunders says in his *Survey of Physics*, "The arithmetical problem of finding this quantity is similar to the one of finding the weight of a single egg, given the weights of a larger number of paper bags each containing a different and unknown number of eggs."

The significance of Millikan's discovery lies in the fact that he proved electricity, like matter, was atomic in nature. That is to say, he proved that electrical charges on bodies were integral multiples of some elementary quantity having a

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[1] Robert A. Millikan, winner of Nobel Prize in Physics for 1923. Now with California Institute of Technology. One of America's most noted physicists. Celebrated for his notable determination of the elementary quantum of electricity by means of his famous oil drop experiments.

definite and fixed value. He concluded that this unit charge was associated with every univalent ion.[2] Let me make clear what is meant by univalent ion. As you probably know, hydrogen in combination has a value of positive one. It is a classic example, when ionized, as in hydrochloric acid, $HCl \rightleftarrows H^+ + Cl^-$ of a univalent ion. With a divalent ion, as, for example, zinc in zinc nitrate, $Zn(NO_3)_2 \rightleftarrows Zn^{++} + 2NO_3^-$ there would be two elementary quantities of electric charge.

This data enables us to compute the number of atoms in a gram mole of any substance (Avogadro's number). Suppose we take one gram mole of hydrochloric acid and place it in an electrolysis apparatus. We shall liberate from this electrolysis exactly one gram atom of hydrogen gas. But the acid furnished exactly one gram ion of hydrogen (H^+) to the negative pole, and associated with this was a definite quantity of electricity, 96,470 coulombs. It is an interesting fact that associated with a gram ion of any univalent substance in electrolysis there are 96,470 coulombs of electricity.[3] Since this is true, and there is a definite number of ions in a gram ion of any substance, it follows that there must be a definite charge associated with each ion. If we can then determine the number of ions in a gram ion, this number will also represent the number of atoms in a gram atom. Therefore $96{,}470 \div 1.591 \times 10^{-19} = 6.06 \times 10^{23}$ atoms per gram atom.

If then, we have 6.06×10^{23} atoms in one gram atom of hydrogen, we will have $2(6.06 \times 10^{23})$ atoms per gram mole. Since in hydrogen there are two atoms to the molecule, it follows that in one gram mole of hydrogen (2.016 grams) there are 6.06×10^{23} molecules, which is the Avogadro number.

Before developing a general statement or formula, and in order to establish with finality the precise connotation of Avogadro's Constant, I wish to submit the definition given in the *Handbook of Chemistry and Physics*, 1933. "Avogadro's Number—The number of molecules in a mole or mass of substance equal numerically to its molecular weight."

With strict reference to the definition of Avogadro's Number as defined above, we are in a position to make a general state-

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[2] Some writers refer to this as the charge associated with the hydrogen atom, or any univalent atom, but in strict adherence to the electron theory, this can not truly be said. Every atom contains equal numbers of protons and electrons, and is therefore electrically neutral. It is to make this distinction that I refer to the elementary quantity as the charge associated with any univalent ion.

[3] The quantity of electricity carried by one gram ion of a univalent element is known as Faraday's Constant or a Faraday. It is 96,470 coulombs.

ment regarding the subject at hand, namely, computing the exact mass in grams of an atom. Associated with a gram mole of any element there are 6.06×10^{23} molecules. This immediately furnishes us the necessary information for computing the mass in grams of a molecule. By knowing the number of atoms in a molecule of an element we can proceed to find the weight of a single atom. A mathematical formulation might serve to clarify this statement. The gram molecular weight of any element divided by the product of Avogadro's Constant times the number of atoms per molecule is equal to the mass in grams of one atom of that element. A formula could be set up as follows:

$$\frac{G.\,M.\,W.}{6.06 \times 10^{23} \times N} = M$$

G.M.W. equals gram molecular weight; N equals the number of atoms per molecule;[4] 6.06×10^{23} is Avogadro's Constant, and M equals the mass in grams of a single atom. I would suggest actual solution be carried out by means of logarithmic notation and that the answers be expressed in powers of ten.

Problem: To determine the weight in grams of one atom of gold.

Data:	Gram molecular weight of Au	197.2 grams
	Atoms per molecule of Au	1 atom

Solution:

$$\frac{197.2}{1 \times 6.06 \times 10^{23}} = M \text{ (grams)}$$

$$\begin{array}{ll|ll}
\text{Log. } 197.2 & = 62.29491 - 60 & \text{Log. } 1.00 & = 30.00000 - 30 \\
-\text{Log. } D & = 53.78247 - 30 & +\text{Log. } 6.06 \times 10^{23} & = 23.78247 \\
\hline
\text{Log. } M & = 8.51244 - 30 & \text{Log. } D & = 53.78247 - 30
\end{array}$$

$M = 3.25 \times 10^{-22}$ grams weight of one atom of gold.

Glossary

Gram mole or *Gram molecule:* The molecular weight expressed in grams. Example—One gram mole of hydrogen is 2.016 grams.

Gram atom: The Atomic weight expressed in grams. Example—One gram atom of hydrogen is 1.008 grams.

Gram ion: The amount of ion produced by the ionization of one gram atom.

[4] The number of atoms in a molecule of an element can be determined by inspection of its correct formula.

Example—In the ionization of one gram mole of NaCl, one gram mole of NaCl would furnish one gram ion of sodium (Na^+) since a gram mole of NaCl contains one gram atom of sodium. $NaCl \rightleftarrows Na^+Cl^-$.

Electro static unit: The electro static unit of charge is that charge which placed at a distance of one centimeter from a similar charge in a vacuum will experience a force action of one dyne.

Coulomb: The coulomb, the practical unit of charge, is the quantity carried by one ampere flowing for one second.

Univalent ion: An ion which results from the dissociation of a substance containing a univalent atom.

Examples—$NaCl \rightleftarrows Na^+ + Cl^-$ both the sodium and chlorine atoms in NaCl have a valence of one and they are said to be univalent. The sodium ion is therefore a univalent ion. Also,

$$Na_2SO_4 \rightleftarrows 2Na^+ + SO_4^=$$
$$H_2SO_4 \rightleftarrows 2H^+ + SO_4^=$$

ATOMS IN ACTION

No. III. The Sleeping Energy of Atoms

By W. T. Skilling
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The phenomena of radioactivity show that great stores of energy must be locked up within the atom. The alpha particle shot from an atom of radium is, in proportion to its weight, about a hundred million times as energetic as a rifle ball. The fact that radium is a continuous source of heat indicates that the vast store of atomic energy is slowly leaking out.

For a long time scientists have known that a tremendous amount of energy lurks within all sorts of matter and have suggested that if some way of obtaining it at will could be invented our power problems would be solved. But until recently the only source of this internal energy has been the radioactive elements. Man has never found a throttle on which he can step to hasten this process of radioactivity. And he has never found a brake to retard it.

The first step ever taken in the way of tapping this hidden inner source of power was by Rutherford in 1919. He succeeded in breaking into the nucleus of certain of the lighter elements, which are not radioactive, by bombarding them with alpha particles shot with great force from a product of radium.

The alpha particles knocked from nitrogen and other ele-

ments were hydrogen nuclei, thus changing the element bombarded and making another new element, hydrogen.

In 1932 a further step was taken, which opened a way by a purely artificial means to break into Nature's storehouse, the nucleus, and release some of the locked up energy there. Rutherford had used a natural product of radioactivity the alpha particle, as a hammer to break the atom but the new hammer is given its force artificially. It is the proton, the nucleus of the hydrogen atom which is made to move at a tremendous velocity by electric means, and is shot against atoms of other elements. Not only are these atoms broken but in rearranging the broken pieces of the nucleus a great quantity of surplus *energy* is given off.

This would seem a solution of the long unsolved problem of obtaining atomic energy, for with a projectile of some 500,000 volts energy 16,000,000 volts of new energy is liberated from the atom struck. But there is still a fly in the ointment. Most of the projectiles do not strike anything. The nuclei of the atoms are so small, and there is so much room between them that only one proton out of about 200,000,000 collides with a nucleus, wrecking it. This process of shooting at the atomic nuclei with swift flying protons is to be compared with random rifle shooting at birds known to be flying somewhere in the air. A large amount of amunition would be wasted for every lucky bullet that strikes a bird.

It is just barely possible that having once found a key to unlock a little of the atomic energy so carefully guarded by Nature other more efficient means will be discovered for making this sort of energy available commercially. But already the scientist has had some reward in the light that his experiments have thrown upon previously formulated theories.

For some time scientists have held that mass can be transformed into energy, and perhaps energy into mass. Einstein, as a part of his theory of relativity devised a simple formula which he said should show quantitatively the relation between mass and energy. His formula was $E = Mc^2$, in which E is energy (expressed in ergs), M is mass (in grams), and c is the velocity of light (3×10^{10} cm per second). The above experiment turns out to be a beautiful proof of this theory.

When the nucleus of the hydrogen atom, the proton, is shot against the nucleus of the lithium atom, for example, it sticks, giving the lithium atom a nucleus of 8 protons instead of 7.

These eight instantly break in two forming two atoms of helium, with 4 protons each and liberating as above mentioned 16,000,000 volts of energy.

Now the remarkable thing about the process is that the mass of the combined particles has become less. The eight protons in the two newly made atoms of helium weigh less than they did before when they were in the form of hydrogen and lithium. They weigh just enough less so that if the difference in mass is substituted for M in Einstein's equation, and the energy set free is substituted for E the equation balances. Mass is equivalent to energy according to the terms of exchange proposed in the equation.

This remarkable proportionality between mass and energy has found application in a process that is supposed to go on somewhere in the universe by which helium and other elements are made from hydrogen. Perhaps, as Millikan suggests the birth of atoms may take place out in interstellar space, giving rise to the "cosmic rays." Perhaps Eddington and others are right in attributing a part, at least, of the heat of the sun and stars to such an action made possible by the terrific turmoil of their superheated interiors.

In any event if, and wherever, the combination of hydrogen atoms into groups of four to form helium atoms, *does* take place, the scientist has a simple equation by which he may find the quantity of heat (or other form of energy) produced. He knows, for example, that the helium atom weighs approximately 4 (in terms of oxygen taken as 16) and that the hydrogen atom weighs nearly 1.008. The shrinkage, then, that takes place in changing from four separate atoms into one atom of four parts is .032. If this be substituted for M in Einstein's equation then E, the energy produced by the conversion of a gram of hydrogen into helium turns out to be, in units of heat, 1.7×10^{11} calories. This is about the amount of heat produced by burning 20 tons of good coal or 5,000,000 grams of hydrogen.

In constructing atoms of other elements the helium nucleus seems to be an important building block rather than the smaller proton. One evidence of this is that it is the helium nucleus, called the alpha particle, rather than the nucleus of hydrogen that is thrown out of the radioactive atoms. This quadruple structure seems to be a very stable group of protons, due, no doubt, to the large amount of heat given out in making it. In the formation of the very stable compounds such as H_2O and

CO_2 by the burning of hydrogen, carbon, etc., a great deal of heat is generated at the moment when their atoms unite. Comparatively little heat seems to be produced in putting together the helium nuclei (and in some cases a few protons), to form the atoms of larger atomic weight than four. In case of some elements it is not certain whether heat is liberated or absorbed in the process.

The most striking possible transformation of mass into energy remains to be mentioned. Above we saw that the change of a gram of hydrogen into helium would produce 5,000,000 times as much energy as the burning of the gram of hydrogen would do. This energy comes from a shrinkage of 1.008 grams to 1 gram, a reduction of only 1/125 of the hydrogen's original mass. But suppose a gram of hydrogen, or of anything else, could in some way be entirely destroyed—annihilated. The amount of energy liberated would obviously be 125 times as great as if it lost only 1/125 of its mass. The atom would cease to exist as mass but would be instantly reborn as energy.

In the language of a historic seeker after spiritual truth we may say, "How can these things be?" If we assume that an atom is wholly electrical in nature and not simply made up of particles *charged* with electricity, annihilation of matter is theoretically quite simple. We have but to imagine something like a head on collision of a negative particle of electricity, an electron, and a positive particle of electricity, a proton, and to suppose that they came so close together as to neutralize each other. Then there would be nothing left but the dart of energy resulting from the collision.

The energy resulting from the total destruction of a gram of matter would be equivalent to more than 600,000,000 times the amount of heat obtained from the burning of a gram of the most efficient fuel, hydrogen.

This fabulous energy may always remain as unattainable by us as is the apparent water seen in a mirage. But though conditions on the earth seem to prevent our control of this energy supply there is every reason to suppose that in the sun and stars, where temperatures are up in the millions of degrees, new atoms may be forming, and possibly old atoms are being annihilated.

A generation ago Helmholtz believed that the sun's continued supply of heat is due to its continually being compressed into smaller volume by the force of its inward gravitational pull.

Calculation shows that this process would supply it with heat for as long a time as geologists of Helmholtz' day regarded necessary. They were like the early surveyors who laid off the wilderness a distance of ten miles to the west of Boston and reported that they had gone as far as surveys would ever be necessary. Geologists of today using new data have multiplied the probable age of the earth by more than 20. This increased period could not be provided for by heat due to contraction. A new source is found necessary and the conversion of mass into energy has been selected as the most probable source.

But whatever be the source which supplies the sun with its ability to shine, it is certain that it is radiating away a quantity of energy that is equivalent to a tremendous loss of mass annually—or even hourly, or momently. The sun's total radiation is computed to be about 10^{26} calories per second. This is equivalent, according to Einstein's equation $E=Mc^2$, to more than 4,000,000 tons per second. By this amount the sun is reducing its weight each second. It seems at first thought incredible, but a little calculation shows that even at this rate the sun would not be all gone for 20,000,000,000,000 years.

Referring to our caption with which this discussion began, we might say that the best advice to give scientists who are endeavoring to awaken this sleeping energy would be to let sleeping dogs lie. Certainly if any considerable quantity of matter could be suddenly wakened into energy TNT would lose its reputation for violence, if, indeed, any of the inhabitants of the earth remained to draw any such deductions.

So little is as yet known about what goes on inside the nucleus of the atom that possibly the word sleeping is a misnomer for the apparently quiescent condition there. As in the pupa, the "resting" stage of the butterfly, in which the larva changes to a winged insect, there may be in action within the nucleus of the atom some very real form of energy too securely hidden away to be observable or measurable.

AIRLESS BRICKS

At the recent meeting of the American Institute of Chemical Engineers Mr. W. F. Rochow of the Harbison-Walker Refractories Company, Pittsburgh reported on the use of airless bricks. Bricks from which the air has been extracted by the vacuum process are now being manufactured and put to use in many industries.

Fire-proof brick for lining blast furnaces and other structures subjected to high temperature is improved by the vacuum process.

PLASTIC BIOLOGY

By Alfred F. Nixon
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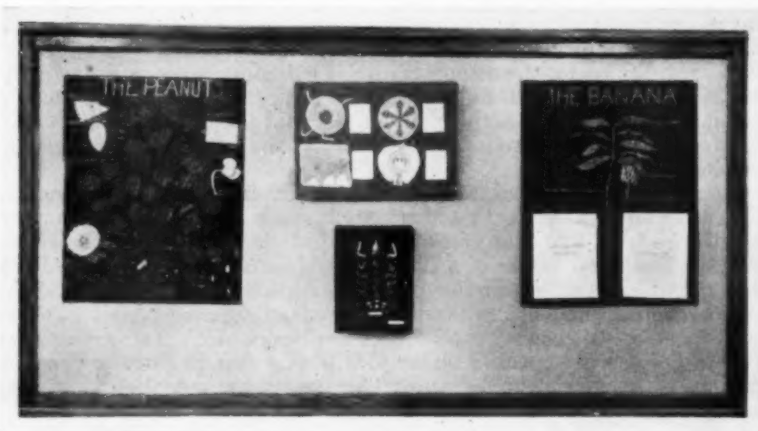
Biology is one of the few subjects in the modern curriculum which lends itself to plastic representation. In my years of teaching experience I have found it a great aid not only in stimulating interest, but in discovering whether or not students have the correct conceptions of certain things taught. It is wise to keep permoplast clay on hand and ask certain students, concerning whom there might be some doubt as to whether or not they understand a certain structure, to make a model of it. These models need not be perfect, but done just well enough to show that the student has the correct conception.

Students who are unusually good at modeling, etc., may be allowed to make permanent models to be used as teaching aids



in future classes. One student made the remark that he intended to make a model so permanent that it would be in use when his children studied biology. Another student who did work which lasted well has gone to college and returned to do her practice teaching, using the project which she did as a teaching aid.

Many so-called lazy and disinterested students may be awakened to do good work simply by introducing the plastic idea. A teacher using some initiative may work wonders through the proper use of this method. There are numerous media through which children might express their ideas.

The illustration shows work done by students. These projects and others of a similar nature include objects done in clay, flour and salt, tin, wood carving, crepe paper, plaster of Paris, paper cuttings, embroidery, and cheese-cloth cuttings. The skeleton of the crayfish was dissected and glued onto the inner back of box. The sliding glass cover of the box was removed for the sake of photography. Cellophane may also be used for protecting exhibits from dust.

DEMONSTRATIONS OF THE ALTERNATIONS OF A. C. CURRENT

By Paul E. Wilson, *Missoula County High School, Missoula, Montana*

Changes occurring at the rate of 60 times per second are usually hard to show. When one talks to a physics class about the current in the ordinary 110 volt light circuit alternating 60 times a second, it is more impressive if this rapid change can be shown.

One quite satisfactory method takes very little equipment. The articles required are: extension cord to 110 volt A. C. outlet, ordinary 60 watt lamp, and a 2 watt neon glow lamp. (Central Scientific Catalogue #8216 is the one I use.) The latter can be obtained from most firms dealing in electrical laboratory apparatus for 65 cents. The better the room can be darkened, the better the demonstration. First connect the ordinary lamp to the flexible cord and move it rapidly back and forth parallel to the seating of the class. On account of the fact that the filament doesn't cool between the alternations of the current, a continuous flash of light is produced.

Then remove the 60 watt lamp and place the neon lamp in the socket. The filament is a disc with a crack through the center rather than the usual wire type. Place the crack in a vertical plane and repeat the above motion. The effect is that of a streak of light broken into segments. Each break represents an alternation of the current. By changing the position of the lamp in the hand so that the crack is in different positions, other unusual effects such as a "rope" effect can be produced. These effects are due to a peculiarity of this neon lamp. When the current stops flowing, the filament stops glowing immediately. The contrast between these two lamps brings out the difference very nicely.

LONG-RANGE CAMERA USES MIRRORS INSTEAD OF LENS

A telephoto camera, adapted for either motion or still photography, using a short reflecting telescope instead of the customary combination of refracting lenses, is described in the German scientific weekly, *Die Umschau*, by an author who signs himself, merely "Th.M."

In a reflecting telescope a pair of mirrors is used instead of the conventional lenses, for the purpose of focusing the image on the camera film or the observer's eye. At least one of the lenses must be concave or saucer-shaped, to bend the light rays aside and bring them to a point or focus. In the new German camera both lenses are concave, increasing the magnifying power for a given length of tube.

A further advantage claimed for the new machine is light weight in proportion to the magnifying power.—*Science Service.*

TEACHING SCIENTIFIC METHOD

Article VII: The Scientific Method in the Classroom

By Ellsworth S. Obourn
John Burroughs School, Clayton, Missouri

The past fifteen years of science education have witnessed an interesting swing in the points of view and philosophy of science teaching for the secondary school levels. Bulletin 26, 1918, of the Bureau of Education, Department of Interior, set up a philosophy of goals stated more or less in terms of the practical needs of the learner. The Thirty First Yearbook of the National Society for the Study of Education sets up a scheme of goals, for the most part, stated in terms of broad understandings which are to be achieved by the learner through recurrent experiences on various grade levels.

The committees which prepared the bulletins mentioned above have been conscious of the need for developing scientific attitudes and habits of thinking but have failed to give the emphasis to these more intangible goals that has been given to other aspects of the suggested programs for teaching science. The reason for this is obvious. We know too little about effective ways and means of realizing these important outcomes from classroom instruction. It is encouraging to note that there seems to be a movement in progress to learn more about these aspects of learning both through the teachers' experiences and through experimentation.

It would seem to the writer that the two diverse points of view represented by Bulletin 26 and The Thirty First Yearbook as set forth, above are apparent rather than real, for no one would deny that the possession of a scientific attitude of mind must be backed in the thinking of the individual with fundamental understanding of the broad concepts found in the various fields of science. This implies, of course, the mastery of the laws, facts, and principles which must build together to give meaning to the broad concepts.

And it is further obvious that while courses of study in the various sciences are being formulated in terms of basic concepts aimed at largely from mature thinking and point of view, the immediate interests, needs, and appreciations of the learner must be kept constantly in view. Understanding of an interrelated framework of broad concepts can be realized only as

we approach them through the real life interests and needs of the learner. The emphasis therefore on the practical, every-day science materials by Bulletin 26 becomes an essential means to the end of the realization of the broad concepts emphasized in The Thirty First Year Book.

In a program of science teaching, therefore, which aims at some realization of a scientific attitude toward life we must build mastered learning experiences made up of the real life science problems of the learner. The careful integration of such practical experiences will then build into appreciation and understanding for the larger concepts of science.

Ordinarily we stop at this point in the learning cycle. We bring the student up to a realization of the broad understanding of science and leave him stranded and bewildered in the face of new science experiences which demand adjustment. It seems to the writer that just as the learning cycle starts with the practical problems of the learner it must end by setting up learning experiences which will demand the application of learning acquisition. We must see to it that the student understands this step of application and guide him in taking it. Realization of these phases of learning should help us to guide our students effectively toward the realization of a scientific attitude of mind.

If the scientific method of thinking is a habit, then its development in a learner must be achieved through the recognized means of habit formation. This is generally recognized to be understanding and use. This would seem to demand that learners be confronted constantly with challenging problem experiences taken from interesting aspects of their environment which will demand the continued use of the elements of the scientific method in their solution.

From the above analysis it would seem that teaching the scientific method of thinking to students would be simple. Confront them with problems and after a period of time the habit is formed. In practice, however, it is another thing. It is one of the most subtle and elusive goals to reach because of the many factors which enter into it. The teacher, the materials for learning, the class itself—all are variable conditions any one of which may eliminate the atmosphere of problem solving and scientific thinking.

The problems for solution should be selected according to the degree to which they demand the use of the scientific method in their solution. It is also essential to so state these problems that

they will at once challenge the interest and enlist the complete cooperation of the student.

In setting up a learning cycle in the classroom which will be effective in creating an atmosphere for scientific thinking, it is essential to integrate the various teaching devices available in such a manner that they will contribute to the realization of the desired goal. The work of the laboratory must be so woven into the development of a problem that the experiment will shed its light at the proper time. Students no longer should be sent to the laboratory for meaningless busy work of verification of laws or illustrations of known principles. They should discover first hand knowledge which will aid in the solution of the problem which has challenged their interest.

The readings on any problem should be definitely pointed by the instructor toward the solution. Wide reading to secure different points of view and material related to the problem should be encouraged. Students should be alert to current sources of material which might aid in the solution of the problem.

The discussion or recitation period offers one of the most valuable opportunities for fostering and encouraging some of the essential aspects of scientific thinking. Students should be encouraged in these periods to maintain an intelligently critical attitude toward responses of their fellow students. This has proven a workable device for keeping keen-edge alertness at all times in the discussion period. The teacher should always maintain a friendly critical attitude toward tendencies of loose thinking, jumping at conclusions, and irrelevant data suggested. Students soon learn in such an atmosphere that suspended judgment is better than snap judgment. The writer feels more encouraged by the results obtained from such discussion periods than from any other device which he has used in consciously attempting to inculcate some degree of scientific thinking.

Another effective means of developing scientific mindedness is to lead a class step by step to the understanding of some concept by use of the scientific method. One such attempt used with some degree of success by the writer is briefly suggested below.

In developing meaning and understanding for the kinetic molecular concept the students after having solved a problem concerning the size and numbers of molecules were introduced to the following experimental demonstrations. Each student was asked to record in notes a careful drawing of the equipment

set-up used in each experiment and also accurate notes on procedure and results.

1. Diffusion of bromine in a tall covered hydrometer jar.
2. Diffusion of illuminating gas through unglazed porcelain.
3. Diffusion of potassium permanganate from the bottom of a tall hydrometer jar filled with water.
4. Diffusion of methylene blue in the same manner.
5. Diffusion downward of a solution of aniline red in alcohol carefully placed on the surface of water in a tall hydrometer jar.
6. Osmosis with any type of osmometer.
7. The melting of ice to water and the changing of it to steam.
8. Brownian movements in smoke particles through a microscope.
9. The sublimation of solid iodine.

Following these demonstrations each student was required to frame a hypothesis of molecular behavior which might account for the observed phenomena. The suggested hypotheses were examined critically in class and discarded as they failed to explain any of the observed phenomena. The hypothesis that molecules must be moving was the result of the discussion. Students were next asked to suggest ways in which the hypothesis might be tested by experiment. The instructor must lead and guide the thinking carefully at this point. A demonstration suggested was to place an open bottle of hydrogen over an open bottle of carbon dioxide and after a few moments to test each bottle with a glowing splint. This was done to confirm the hypothesis.

The complete clinching of the understanding was attained in a demonstration with an evacuated tube containing mercury and glass beads which when heated illustrated the molecular condition of solid, liquid, and gas.

This brief summary has of necessity omitted many important concomitants which develop in the lesson, such as careful observation, critical analysis of data, suspended judgment, intelligent questioning of hypotheses, and, finally, the listing on the blackboard of conclusions supported by the data and drawn by class discussion.

The writer hopes that this report, which has rambled much, may serve the purpose for which it was intended: namely, to give his point of view and methods of procedure in an attempt to interest boys and girls in reflective thinking.

FLOWERS AND THEIR CLASSIFICATION: SOME SUGGESTIONS

BY ARTHUR M. JOHNSON
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Much has been written in books and periodical literature on "How to know the wild flowers." As long as flowers and the science of botany continue to exist, additions to the already extensive literature on this subject will continue to appear. And it is well that it should be so, for with the progress of the science and with the increased knowledge resulting therefrom new methods of classification and new techniques in the art of presentation of the subject must eventually follow.

How know the flowers? The only way the systematic botanist has ever acquired this knowledge has been by studying the structures of flowers. He has not learned them by memorizing their names,—names which he has learned from his colleagues or from books. No, to the botanist a strange plant possesses certain floral characters which he recognizes as characteristic of certain large groups in which occur certain familiar orders or families, from which he works down quickly to the genus and the species. So in learning how to know the flowers, if the name be all that we want to know, however satisfying and helpful that may be, any device that we can invent to facilitate that objective will in the end very likely defeat its purpose and prove less helpful than the tried and sure method of the botanist.

When we name a plant, we immediately classify it. That is, we associate the plant with some class or group or category,—because it appears to possess certain features or characters that correspond with the characters of that particular category. To the novice these characters may be superficial but to the botanist they lie in the structure of the flower. That is the significant point in learning how to know the flowers. If we know the structures of the flowers of the category in which a specimen belongs we shall find little difficulty in identifying the specimen. But the learner has somehow become possessed of the notion that in order to know what the botanist knows a staggering amount of detailed "technical" knowledge is necessary. True, some detailed knowledge is essential, but it can be far from technical and certainly far from staggering or discouraging. Reduced to their essentials or fundamentals the necessary informa-

tion can be acquired with a reasonable expenditure of effort. These essentials involve simply a knowledge of the organography or structural make-up of a relatively few general types of flowers, and especially of those types which are representative of the major groups. And the vocabulary necessary for the description of these types is by no means such as to discourage any one. When we become accustomed to working with flowers, descriptive terms will fix themselves in our memory without much effort on our part.

The books at our disposal for the study of the classification of plants are many and varied. Besides the standard "manuals" or "floras" there are many popular "guides" which aim to facilitate the identification or "naming" of flowers. The manuals follow some accepted system of classification, and usually cover the flora of a considerable geographic area. Naturally, the more extensive the area covered, the greater will probably be the number of families, genera, and species, described. But the size of the manual should not discourage even the beginner, because the principles underlying the classification of the flowering plants (Angiosperms) are the same for any system based on natural relationships, although there may not be unanimity as to the exact relationships or delimitations of groups, and hence some differences in the sequences of orders, families, etc., may appear. But whether we use a natural (phylogenetic) or an artificial system makes little difference. An artificial system may sometimes be the simpler and therefore the easier to operate. The dictates of convenience often makes the artificial system preferable. It is the system made use of in one form or another in most popular "guides." A combination of both systems will be found in some manuals. But to understand the operation of any system it is necessary to study it. It is a profitable exercise in a course in "flower analysis" to require the class to make both a natural and artificial grouping of the plants studied. In other words, to construct a natural "key" and an artificial key to the species. In fact this is as effective as any method of bringing forcefully to the attention of the student the differences and similarities in plants, and the significance of these differences and similarities in classification. At the same time such practice will tend to awaken a wider interest in the subject and lead to a greater appreciation and understanding of classification.

A knowledge of the fundamentals on which the classification of the flowering plants is based is therefore essential to an

understanding of the system used in the standard manuals and "floras." It is not enough to study flowers merely for the sake of knowing their "parts"; it is more important that we know the structural make-up of the flower as a whole, with particular reference to the positional relations of the different sets of organs ("parts"). A study of the manual will show what characters are of major and what of minor importance. Thus in the classification of the flowering plants as a whole, it is the number of cotyledons in the embryo that determines whether a plant shall be classified as a monocotyledon or as a dicotyledon. The number of cotyledons, then, is a character of major importance. To determine this character, however, we need the seeds. But the flowers, and even the foliage of these subdivisions also show characters which serve to distinguish them, and these characters are likewise of major importance. Characters which distinguish genera and species in this relation will then be of minor importance. Again, the type of corolla serves to divide the Dicotyledons into two large groups, so that here the corolla assumes major importance. So we can go on down the line and pick out characters of lesser and lesser importance, setting off smaller and smaller groups, even to subdivisions of species. The habit of correlating the flower types with the different major categories, orders, families, etc., as these occur in the manual will thus enable us to orientate ourselves, the different types of flowers we have learned serving as guide-posts to the particular groups. In some manuals the different classificatory categories, —the families, orders, and larger groups,—are readily located under their proper headings, much to the convenience of teacher and student. The size of the manual in terms of the number of species, genera, families, etc., covered makes no difference, for as far as the major categories are concerned, different manuals using the same system will be similar. A manual on a local flora might be expected to contain fewer species, genera, etc., than one covering a larger territory, but not necessarily, for the local flora might be as rich in species and genera, and even families, as the larger area.

It is always of interest to the botanist when a new manual or a new system of classification appears in print to note how the author has grouped the various categories, or what new ones have been proposed, and in what relation they have been placed with respect to other categories. Much useful information on this subject can be acquired from a comparative study of the

systems used in different manuals. Such study is particularly important to those who desire a deeper insight into the principles of classification, whether for purposes of teaching or for general information.

At this point something may be said on the practice of using the manual without the repeated and laborious reference to the general key. This can be done with a little practice, provided we keep in mind the flower types that are representative of the major groups, and provided further that we have learned where these groups come in the body of the manual. These major groups are relatively so few that they can be learned in short order. We would not look among the Dictotyledons for a flower that has all the characteristics of a lily, nor would we look among the Monocotyledons for a flower that has all the characteristics of a morning-glory. That would seem obvious, yet the writer has seen it done repeatedly by persons who have never learned to work without the "key." We might misplace water-plantains and butter-cups, but the corollas should set us right.

As for the Monocotyledons in general it is a relatively simple matter to place them, if we bear in mind their characteristic floral and vegetative characters. The different families or family groups are sufficiently distinctive to be recognized almost on sight. Most people are sufficiently acquainted with a host of them to recognize them in the field. For example, the cat-tails, the pondweeds, the grasses and sedges, the palms, the aroids, the pineapple, the spiderworts, the rushes and the lilies, the amaryllises and the irises, the bananas, the cannas, and the orchids. These are all "common things." We should not have need of an order or family key to "run down" any of them, if we have informed ourselves on the characters of their flowers; and if we know where they are placed in the manual we can turn directly to the genus key and the species key. By elimination we can work from the known to the unknown. The monocotyledonous families, it will be noticed, are relatively few in number, and because they are quite distinctive, few of them will give us any trouble. The lilies, the amaryllises, and the irises are often confused, it is true, but they should not be if we make it a point to pick out the differentiating characters. Most lilies have six stamens and a superior ovary, the amaryllises six stamens and an inferior ovary, and the irises an inferior ovary and three stamens. The remaining families of the Monocotyledons up to and including the orchids all have irregular corollas, one or more

stamens modified as staminodes, and inferior ovaries. Obviously any flower possessing these characters must come in one or the other of these higher families, that is, it must be, let us say, either a banana, a ginger, a canna, an arrowroot, a Burmannia, or an orchid,—actually very few families to choose from, and fewer still if we eliminate those not represented in our flora. A similar line of procedure can be followed with regard to the families of the lower monocotyledons. We should come to see here that bananas are not "palms" nor are yuccas "cactus-palms!"

With respect to the Dicotyledons the difficulties may appear greater, but on the whole they are not. The two major divisions, the Metachlamydeae (Sympetalae, Gamopetalae) and the Archichlamydeae (Choripetalae, Polypetalae) are clearly differentiated on the characters of the corolla. As previously pointed out, the corolla here being of major importance in classification. The Archichlamydeae constitute by far the larger group. But the lower families of this group can be set off into an easily recognizable subdivision, the Monochlamydeae, characterized in general by very small and inconspicuous flowers in which the corolla resembles the calyx or may be entirely wanting. Technically the flowers are said to possess an undifferentiated perianth. Here we find, among others, the so-called "catkin-bearers" (Amentiferae). The Monochylamydeae do not constitute a large group, nor are they a "natural" group, but a very convenient one for purposes of instruction and getting acquainted with its members. It is like an assemblage of people, all wearing the same type of clothing, but racially distinct. In this assemblage are many common and well-known plants, such as the willows and poplars, the walnuts and hickories, the birches, alders, hornbeams, and hazels, the beeches and the oaks, the elms and the mulberries. These, it will be noticed, are trees or shrubs. But there are also many herbaceous forms, such as the nettles, the mistletoes, the sandalwoods, the buckwheats, the docks and the knotweeds, the goosefoots and the amaranths, the four o'clocks and the purslanes, and lastly the pinks—which, by the possession of a distinct corolla, carry us over into the next higher subdivision of the Archichlamydeae, the Dialypetalae. Some of the members have flowers with inferior ovaries, which enables us to segregate them from the rest where they will stand out more clearly. Other members have perigynous flowers (knotweeds), and these can likewise be segregated to aid the memory. By thus isolating these "advanced" types, canceling

them out so to say, we get a better perspective of the whole group. The reader will recognize many familiar plants in these categories—all confined to a relatively few and rather small families which stand at the beginning of the Dicotyledons (in the generally accepted system of classification). With respect to their floral characters they are as distinctive a group as any within the Archichlamydeae. Because the perianth is so simple they were named the Monochlamydeae,—meaning one-cloaked or one-manteled.

The higher subdivision of the Archichlamydeae, namely the Dialypetalae (or characteristic "Polypetalae"), comprises by far the largest number of families, genera, and species. This large array of forms may appear rather overwhelming, yet if we make even a casual survey of the families in the manual we shall discover a host of common and familiar plants with distinctive floral structures. To name but a few: the water-lilies, magnolias; buttercups, barberries, sassafras; poppies and mustards; saxifrages, strawberries and raspberries, spiraeas, roses, peaches, cherries, and plums, apples, pears, and quinces; peas and beans and clovers; geraniums, "nasturtium," and flax; oranges and lemons; poinsettia, sumacs, hollies, maples, buckeyes, and grapes; mallows and basswoods; violets; cacti; myrtles, and evening primroses; aralias, carrots, parsnips, and dogwoods. In other words, we proceed from flowers with numerous separate and spirally arranged parts, a superior gynoecium (pistil), and more or less undifferentiated perianth, to flowers with few parts in whorls (cyclic), inferior ovary, and distinct calyx and corolla, —that is from a primitive or generalized type to an advanced or specialized type. Here we have two well-defined "landmarks" along the road to a clarification of the group. Other land-marks will appear on inspection. A few queries may stimulate further investigation. Where—that is, in what families—does epigny (inferior ovary) occur? Where perigyny (always associated with a superior ovary)? Where distinct carpels? Where an irregular corolla? Characteristically united stamens? Fleshy fruits? Achenes? Legume fruits? Numerous stamens? Which families can be identified by their stamens alone? Which by their fruits alone? In this way we get a bird's-eye view of the salient landmarks which will enable us to place with reasonable certainty in its proper family some unfamiliar flower belonging in this great group. And we can do so without the use of the general key.

Certain families of this great group stand out so clearly that we can hardly fail to recognize the members. The water-lilies and the magnolias are two of these. And the mustards, with their cruciform corollas, six stamens, and characteristic fruits. So too the carrots and parsnips and their allies,—the "Umbellifers," with their numerous small epigynous flowers arranged in the characteristic "umbels," or umbrella-shaped flower clusters. Then there are the "papilionaceous" peas, the spurges (many with milky sap!), the mallows with their unmistakable columnar staminal column, and the evening primroses with their four-parted calyx and corolla and deeply inferior ovary (compare with the mustards, which have a superior ovary!). Sometimes resemblances are deceptive. Thus, who has not confused a milkwort (Polygala) with the papilionaceous peas? And the cacti with the cactus-like spurges? But such deceptive resemblances only serve to whet our powers of observation. They are interesting "mimics," and make us cautious about jumping to conclusions. And because of their uniqueness they stick to the memory. They are illuminating "signposts."

Another well-marked character which serves as a useful recognition-mark of their kind is a characteristic gland or "disk" which occurs at the base of the ovary in certain families of the two large orders Geraniales and Sapindales of the Dialypetalae. Good examples are to be seen in the citrus group, the sumacs, the maples, the buckeyes, and the buckthorns. Whenever we meet with a flower in which such a disk is present we can be reasonably certain that it will be found in some family belonging in these orders. If the disk is associated with resinous glands on the ovary and on the foliage we shall probably look to the Rue family. Glands of a different type occur also on the ovary in many members of the genus Saxifraga, and in certain members of the Metachlamydeae. But other floral features enter in here to set off our specimens.

Students will probably find the Metachlamydeae (Sympetalae, Gamopetalae) by far the simplest group to work with. The identification of families or family groups here is simplified by the distinctive characters of the corollas, stamens, gynoecia, and fruits. But it will help considerably towards simplification if we observe that the group can be subdivided very conveniently into two major subdivisions, distinguishable by the number of whorls of stamens present. These subdivisions are known as the Pentacyclicae and the Tetracyclicae, the names being

derived from the number of whorls of floral organs present in the flower. A five-whorled flower will have two whorls of stamens, and consequently will come in the Pentacyclicae, while a four-whorled flower, having one whorl of stamens, will come in the Tetracyclicae. With respect to the number of whorls present the general floral formulas of these subdivisions would be respectively: Calyx (1), corolla (1), stamens (1+1), carpels (1); calyx (1); corolla (1), stamens (1+0), carpels (1). It should be pointed out, however, that certain members of the Pentacyclicae have only one whorl of stamens and others have numerous stamens, but these features only help to set these forms off all the more clearly. Besides, the corollas and gynoecia are in themselves distinctive. The forms with only one whorl of stamens can be recognized by the fact that the stamens are opposite the lobes or divisions of the corolla. There is a further advantage in that the families are relatively few in our flora, as an inspection of the manual will show. Besides, many plants belonging here will be familiar, namely—to mention some of commoner ones: the sweet pepperbushes, the wintergreens, the Indian-pipe, the heaths, the blueberries, huckleberries, and cranberries, the rhododendrons and azaleas, the persimmons, the primulas, the sapodillas, the storaxes, and the thrifts.

To simplify the classification further, we may subdivide the Pentacyclicae into two subdivisions according to whether the ovary is superior or inferior. This will set off certain distinctive members,—e.g., the blueberries and their allies and certain members of the primula and storax groups.

There remains the large subdivision, the Tetracyclicae, a group which, in spite of its size, comprises very distinctive families or family groups. But it will simplify matters here, too, if we make a survey of the whole array, and determine which constitute the epigynous-flowered members and which the hypogynous-flowered members. Going further we can easily discover which members of these subdivisions we have made have regular corollas and which have irregular corollas. Thus we have simplified our approach to the group, by setting off certain categories recognizable by certain distinctive floral characters, and furthermore, we have reduced the number of families in each category, which greatly simplifies the finding of them.

Inspection of the manual will show that the epigynous-flowered members of the Tetracyclicae comprise a rather small aggregation of families, in themselves very distinctive and

easily recognized. The group begins with the madders and ends with the composites. Familiar examples are: the madders (Bedstraw), the honeysuckles, the valerians, the teasels, the gourds, the harebell and the Canterbury bell, the lobelias, the sunflowers, goldenrods, asters, thistles, and dandelions. One of the marked features of the group, besides the deeply inferior ovary, is the greatly reduced and often modified calyx—characters which set them off at once. We can hardly go astray on the composites, but certain honeysuckles (Viburnum) bears a strong resemblance to the dogwoods among the Dialypetalae, yet the sympetalous corolla at once sets them off. And if we have studied the flowers and fruits of the common gourds of our gardens we should have little difficulty with our native wild ones.

The remaining members of the Tetracyclicae are all hypogynous-flowered (ovary superior). Although a large group, certain families or family groups are distinctive and, as set forth previously, we can conveniently segregate the regular-flowered from the irregular-flowered members. By so doing we shall find our way among the families speedily. We shall dispense with a "key."

The Tetracyclicae begin with the gentians and the olives and end with the plantains. Among the familiar plants of the series are: the olive, the lilac, the ash, and the gentians, the dogbanes and the milkweeds, the morning-glories and the phloxes, the water-leafs, borages, verbena, and mints, the potatoes, tomatoes, petunias, and Jimson-weeds, the snapdragons and foxgloves, broomrapes, and catalpas, and the plantains. The milky sap and the peculiar flowers of the milkweeds set them off unmistakably, nor can we go astray on the milky-sapped dogbanes. The corollas, stamens, fruits, the odors, and often the square stems set off the mints. So on down the line, each family set off by some distinctive feature of flower and fruit. These "recognition-marks" we should always segregate and learn.

We have thus attempted to point out a method of procedure in learning how to know the flowers. We have attempted to point out certain categories and landmarks whereby, with a little effort in the way of study of representative types of flowers and by all means a careful study of the manual itself, we may acquire the necessary information for guidance. Sometimes we never learn to see the forest for the trees, and this is nowhere truer than in studying the classification of plants. It

should not be so. But the habit of continually resorting to the key in "classifying" flowers, as well as in studying "flower analysis," is likely to lead to just that sort of unprofitable re-results. We must get our bearings if we are to get anywhere. The bearings are marked out by the characters of the major groups. They stand as signposts along the way. Learn the major groups and their subdivisions and the families, genera, and species will follow in the course of time. When a student gets so that he can recognize the family to which a plant belongs we should say that he is a good botanist. He will be a better botanist than if he knew the names of a hundred plants yet could not tell what families they belonged to.

By way of summary and conclusion a few added remarks may be to the point. Let us say that we are using Gray's Manual or Britton and Brown's Manual. We have familiarized ourselves with the organization of the content,—the arrangement and sequence of the major categories, orders, families, etc., and we have studied the organization of the general key at the beginning of each book. What we need to know, primarily, are those fundamental flower types which will enable us to find the major categories and their subdivisions. If we know these and if we have correlated the key with the text of the manual, we shall with a little experience, be prepared to turn quickly to the proper place in the manual where our specimen belongs. To this end the student should have at his command the following important items: (1) the distinctions between a monocotyledonous and a dicotyledonous embryo, and between monocotyledonous and dicotyledonous flowers; (2) the distinctions between sympetalous, choripetalous, and monochlamydeous flowers; (3) the distinctions between hypogynous, perigynous and epigynous flowers, or between superior-ovaried and inferior-ovaried flowers; (4) the distinctions between apocarpous and syncarpous gynoecia (pistils); (5) the distinctions between actinomorphic (regular or radially symmetrical) and zygomorphic (irregular or bilaterally symmetrical) flowers. These are the fundamental major considerations. With these at his command the student can place any flower in its major group, even in the Order, from which it is but a simple step to the family and genus.

As an aid to the student in determining whether his specimen is hypogynous, perigynous, or epigynous, or whether the ovary is superior or inferior, a section of the flower can be cut

longitudinally (vertically) through the center with a knife or scalpel. The cut face will show the organization clearly. The operation is very simple, though a lens may be necessary in case the flower is very small.

AN EXPERIMENTAL COMPARISON OF TWO METHODS OF TEACHING ELEMENTARY ALGEBRA*

By Marguerite Linn
Lynwood, California

The more recent trends in education call for a readjustment of teaching procedure. High school mathematics has come in for its share of criticism, the contention having been advanced that the large number of failures each year indicates either defective teaching methods or too rigid requirements in subject matter.

In the light of this criticism, it seemed a desirable project to attempt to compare in actual practice two outstanding methods of teaching one of the branches of high school mathematics, elementary algebra, with a view of ascertaining which method of instruction would yield the better results. The two methods chosen were the one known as the traditional recitation method, and a modified form of the unit plan.

Procedure. After equating as nearly as possible, two groups of thirty-two students each, all of whom were without previous experience in the field of elementary algebra, one group was taught during the remaining thirty weeks of the school year by the traditional recitation method, while the other was taught by a modified form of the unit plan. The groups were equated on the basis of the scores on three standard tests administered during the first six weeks: the Terman Group Test of Mental Ability, the New Stanford Arithmetic Test, and the New Stanford Reading Test.

The recitation method, as used, consisted in brief of uniform daily assignments, daily consideration of previous assignment, discussion of difficulties, and class drill, with occasional tests.

The modified unit method consisted of a group meeting at the beginning of each part of a unit; several days devoted largely to laboratory work, or supervised study; and a group meeting

* Resume of a thesis presented to the Faculty of the School of Education, University of Southern California, in partial fulfillment of the requirements for the degree Master of Science in Education.

at the end of each unit for the purpose of discussion and testing. Graded assignments were used, each student choosing the group in which he wished to work.

Achievement was measured by means of Douglass Standard Survey Tests I and II, Form A. These were given at the end of the first semester and at the end of the school year respectively, for the purpose of determining which of the two methods used yielded the better tangible results. Twelve supplementary tests were also given during the year, and records of these served as a check on the results of the standard tests.

Results. On the standard achievement test at the end of the first semester, the unit group had a slightly higher average, (0.6 point), while on the second test of the same type, at the end of the year, the recitation group was 0.2 point higher. Both differences were found to be reliable. On eight of the twelve non-standardized tests, the unit group ranked higher, but in four the recitation group average was superior. The type of work on which the recitation group excelled seemed to be the more difficult mechanical processes.

At the close of the school year, a vote was requested of the students from the unit group, as to which method they preferred. The opinions expressed showed a majority of almost two to one for the unit method. The ratio of preference increased in direct proportion to grades—that is, the higher the grades, the greater the ratio of preference for the unit method.

Conclusions. If achievement or subject matter mastery were the only factor to be considered, there can be little doubt that, in so far as the limited scope of the experiment in question permits of conclusions, there is little if any difference in results to be obtained by the use of the recitation method or of the modified unit plan.

However, two other important elements which should be taken into consideration are the attitude of the students toward the two methods, and the more subtle qualities, such as initiative and self-dependence, which may result from the difference in method.

Regarding the first of these, the attitude of the students toward the two methods, as was stated, a decided preference was indicated toward the unit plan as against the traditional recitation method.

As for the second factor, which might be termed character-building, conclusions must of necessity be of a purely subjective

nature. There are certain characteristics of the unit method, which, in the opinion of the writer, tend to develop in the student independence of thought and action, initiative, intellectual honesty, and self-dependence. That these are valuable contributions to the education of the student cannot be doubted.

The general conclusions to which the writer has come in the course of this experiment are: first, that the success or failure of any method of teaching depends to a large extent on the personality and initiative of the teacher; second, that all methods have their merits, and that there is no one which can be used in all situations, under all circumstances, with an equal degree of success.

INVENTOR'S INSTITUTE LISTS 895 NEEDED INVENTIONS

With every person a potential inventor and many taking the matter seriously, the Institute of Patentees compiled a list of 895 needed inventions in connection with its recent Tenth International Exhibition of Inventions here.

Someone ought to invent, for example:

1. An instrument for showing the pressure in automobile tires at sight without having to remove a valve cap.
2. A cheap photo-electric cell to fit inside the bulb of an automobile headlight so that the light would be dimmed at the approach of another car.
3. A captive golf ball for use in winter to indicate where it would have landed if played in the ordinary way.
4. A non-skid road.
5. Some form of table napkin with strings that will not slip off the knees.
6. A cheap automatic device to awaken the deaf.

PUREST WATER WEIGHS TWELVE PARTS PER MILLION LESS THAN KIND MAN DRINKS

"Protium Oxide," purest water yet prepared, practically free from "deuterium oxide" which contains the double-weight hydrogen variety, is lighter than the common drinking water by about 12 parts per million. Ordinary water contains about one part in 9000 of heavy water, according to the group of investigators who carried out the extensive purification in connection with the work here described.

E. H. and Prof. C. K. Ingold at University College, London, and H. Whitaker and Prof. R. Whytlaw-Gray at the University of Leeds, purified London and Leeds tap water by fractional distillation, electrolysis and decomposition with metals, until it contained at the most a few units per cent of the original heavy water.

The discovery of heavy water has involved many changes in the chemist's and physicist's "constants." Even the atomic weights of hydrogen and oxygen, among the most accurately known, need slight alterations. The scientists point out in their communication to the scientific periodical Nature that it is doubtful whether the ratio of the weight of hydrogen to oxygen has ever been determined using gases of normal composition. *Science Service.*

ELECTROLYTIC EXPERIMENTS IN HIGH SCHOOL CHEMISTRY

By Harold J. Abrahams
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Inspection of high school laboratory manuals in chemistry reveals the fact that very little or no opportunity is generally provided for electrochemical experiments. It is quite probable, however, that first-hand experience with the chemical effects of the electric current can be of excellent value to high school students both because such studies tend to enhance their interest in chemistry and because they facilitate the comprehension of many of the basic concepts of this science. Furthermore, students who have conducted a few interesting electrochemical experiments, are apt to approach the study of electricity with greater anticipation. The experiments herein described have been developed with these thoughts in mind and have been used with about forty students over the last two years.

The laboratory in which these experiments are carried out, is furnished with direct current. An inexpensive arrangement of wiring for six pairs of students, is shown in Figure 1.

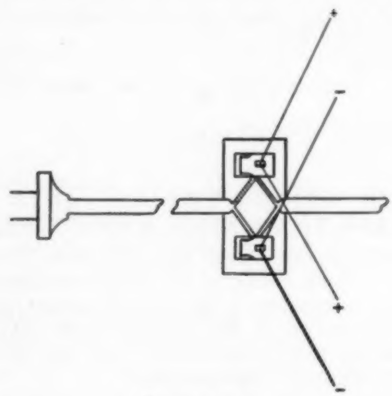


Figure 1

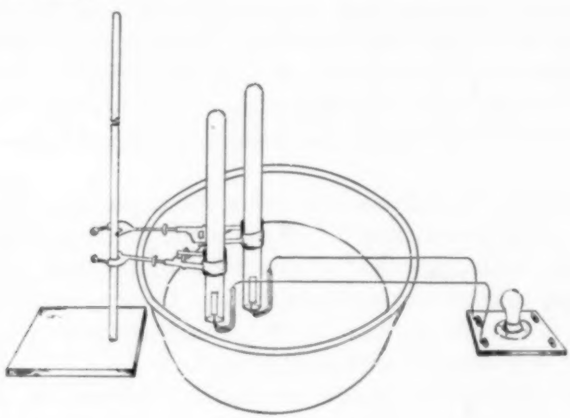
Recently the laboratory tables have been rewired, each with three polarized receptacles on either side, so as to make the six groups at each table entirely independent of each other.

I. *Electrolysis of Water.*

A. *Preparation of Hydrogen and Oxygen.*

The apparatus is arranged as in figure 2. Care must be taken to select test tubes of approximately the same size, as the variation in diameters of six-inch tubes may often be great enough to give what appear to be incorrect quantities of hydrogen and oxygen.

The electrodes consist of strips of hard-rolled platinum foil, 7×25 mm., mounted in glass connection tubing by platinum wires of 4 cms. length. The platinum wires are extended by being soldered on to copper wires of length great enough to pass through the open end of the glass tubing which measures about 12 cms. in height.



STUDENT APPARATUS FOR THE ELECTROLYSIS OF WATER

FIGURE 2

A number of advantages are gained by the use of platinum. The wires leading to the electrodes may readily be encased in glass tubing and thus allow electrolysis to take place only from the electrode surface, so that none of the products can escape being collected. Furthermore, platinum electrodes do not take part in secondary electrode processes and thus neither lose their period of usefulness nor upset the quantitative relationship of hydrogen and oxygen. Copper electrodes, for example, are open to the objection that they permit tremendous oxidation at the anode, if sodium hydroxide be used as electrolyte, with the result of almost complete absorption of the oxygen. Lead electrodes in sulphuric acid would of course also be unsatisfactory. Such electrodes may however be used with sodium hydroxide, with fairly good results. In this case the electrode is cylindrical

in form, 1 cm. in diameter and 3 cms. high, giving a maximum exposed surface. However, with platinum at its relatively low market price, the cost of equipping a laboratory with 18 pairs of such electrodes is not prohibitive. The use of copper extending wires inside the glass tubing effects an appreciable saving.

For electrolyte 0.5 to 1.0% sulphuric acid is very satisfactory, giving rapid results and being very clear in appearance during electrolysis, so as to permit observation of the progress of the reaction. It is of course useless with pneumatic troughs made of metal or with imperfect enamel-ware.

Sulphuric acid may be replaced by sodium hydroxide of the same strength, but the high surface tension of solutions of the latter electrolyte cause such a frothing inside the test tubes that the progress of the electrolysis is greatly obscured. Furthermore, observations in this laboratory seem to indicate that the electrolysis time is longer, using sodium hydroxide as electrolyte.

Students in this laboratory, using the apparatus described, obtain a six-inch test-tube full of hydrogen in five minutes with a 100 watt lamp (in series) or in eight minutes with a 60 watt lamp, using sulphuric acid as electrolyte. Using sodium hydroxide, they obtain the same results in 7 minutes with a 100 watt lamp and in 9 minutes with a 60 watt lamp.

A crude verification of the volumetric composition of water may be made, by having students measure the volume of the gases in the tubes, at any time during the experiment. When the hydrogen tube is full, the tubes are removed and the gases in them are tested for with flame and spark respectively.

B. *Preparation of an explosive mixture of hydrogen and oxygen.*

The apparatus is set up again and allowed to proceed as before, until the hydrogen tube is two-thirds full. The polarity is now reversed, by suitable exchange of wires at the Fahnestock clips of the lamp-bank. When both tubes are full, their contents are, of course, identical, i.e., 2 volumes of hydrogen to 1 volume of oxygen. A flame is applied to each tube.

Among several values of this experiment is the vivid experience of the complete control which the chemist frequently has over directing electrochemical processes.

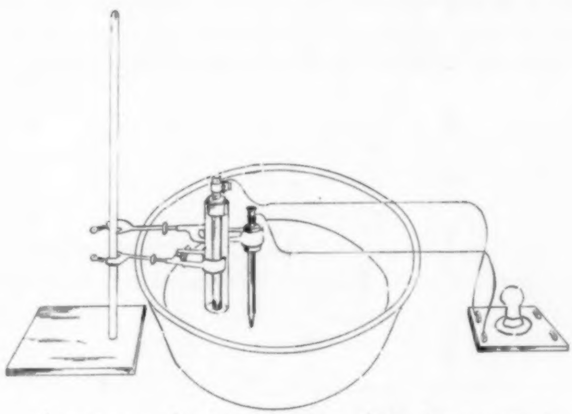
Another advantage is the sharpness of the report resulting from the explosion—it is very easy for students to obtain the correct mixture and thus benefit by the satisfaction which a

successfully performed experiment gives beginners in this science. As ordinarily performed, this experiment makes use of a test tube five-sevenths full of air and two-sevenths full of hydrogen. The tube is thus less than half full of reacting gases. In the electrolytic mixture the tube is entirely full of reactants.

A third general outcome of such experiments is the better opportunity for student-teacher contact in the case of students with inclinations along electrochemical lines.

II. *Electrolysis of Sodium Chloride solution.*

The apparatus is arranged as shown in figure 3. The cathode is an iron "spike," mounted in a cork. The anode is a graphite rod, 10 cms. long and 1 cm. in diameter, inserted into a rubber



STUDENT APPARATUS FOR THE ELECTROLYSIS of SODIUM CHLORIDE SOLUTION

FIGURE 3

stopper. The stopper, in turn, is inserted into the flanged mouth of a bottomless test tube, made by cutting the upper 11 cms. from an 8 inch test tube, if not available from dealers. The electrolyte consists of a saturated (approximately 6 molar) solution of sodium chloride in water.

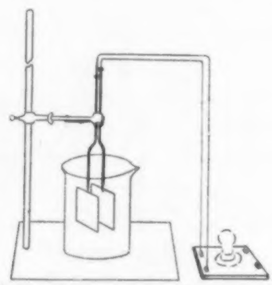
Using a 100 watt lamp, students in this laboratory obtain a tube of chlorine gas in about 15 minutes.

During electrolysis a few drops of phenolphthalein indicator are placed at the cathode to detect sodium hydroxide. The striking result obtained here seldom fails to influence the most indifferent student. At the same time it gives confirmation to

the fact, previously learned in class, that lye is a by-product in the manufacture of hydrogen and chlorine.

At the conclusion of the electrolysis the tube is removed, a small piece of moist paper, bearing newsprint, red ink and pencil markings is inserted and the tube then stoppered at both ends, to study the bleaching effects of chlorine.

It has also been found instructive to set up two demonstration cells, using potassium bromide and potassium iodide, which operate while students are preparing their chlorine. These cells differ from student apparatus only in that glass troughs, fitted with asbestos diaphragms across the center, are substituted for pans. The concentrations are about 0.4 molar potassium bromide and 0.6 molar potassium iodide. Halogen forms in one compartment and permits of the easier detection of potassium hydroxide in the other compartment. Students thus become familiar with the three halogen elements at one time and receive



Student Apparatus for the Electrolysis of Copper Sulphate Solution

FIGURE 4

an orientation to this family of elements. From their observations on the contrast in colors of the free halogens and their ions, they also have a basis for recall, when later studying the theory of ionization, that ions and molecules of the same element differ from each other in appearance. The more alert students frequently suggest a halide-phenolphthalein mixture for determining the polarity of a cell, after performing this experiment, showing that it has proved thought-provoking to them.

III. *Electrolysis of Copper Sulphate Solution.*

The apparatus is arranged as shown in figure 4.

The electrodes are copper plates 3.5 cms. square. A perfora-

tion, near the top, allows the plate to be suspended from the hook of the connecting wire, two of which are mounted in a two-perforation stopper. The electrolyte is 15% Copper Sulphate solution, containing a trace of free sulphuric acid. With a 60 watt lamp in series, 0.200 gm. of copper may be deposited in less than 30 minutes. The experiment is made "quantitative" by dipping the plates in boiling distilled water, allowing them to drain off, then dipping again in two containers of alcohol and finally in ether, draining again each time. They are then handled entirely with forceps, being weighed on a triple-beam balance. At the end of the experiment they receive the same treatment and are weighed again.

Table I shows a few typical results obtained in this laboratory.

TABLE I
CHANGE OF WEIGHT AT ELECTRODES

Experiment No.	*1*	*2*	*3*	*4*	*5*	*6*
Gain at Cathode in gms.	0.450	0.550	0.478	0.500	0.540	0.500
Loss at Anode in gms.	0.470	0.520	0.520	0.470	0.520	0.500

These results tend to confirm the essential correctness of the statement that the deposited metal is merely transferred from the anode in this experiment, the composition of the bath remaining constant. Students thus have their knowledge of electro-deposition of metals enriched.

TABLE II
CONFIRMATION OF FARADAY'S LAW BY TYPICAL GROUPS

Student-Group	*Time Minutes*	*Amperage*	*Wattage*	*Gain at Cathode in gms.*	*Quantity required by Faraday's Law—W*	*Approximate Error (%)*
1	30	0.80	100	0.450	0.475	−5
2	30	0.90	100	0.550	0.535	+3
3	30	0.82	100	0.478	0.487	−2
4	30	0.81	100	0.500	0.481	+4
5	30	0.80	100	0.460	0.475	−3
6	30	0.87	100	0.500	0.517	−3

By placing an ammeter in series in the circuit, it is also possible to use this experiment for teaching and verifying Faraday's Law. Table II shows a few results.

W (in table II) the weight of copper required by Faraday's Law, was calculated by means of the relationship $W = \dfrac{I \times t \times E}{96{,}500}$ where I is the number of amperes flowing during time (in seconds) "t," and E is the equivalent weight of copper.

At the conclusion of the quantitative phase of this experiment, the polarity may be reversed and the cathode "stripped" though very small fragments may become detached from it. In addition to the theoretical values suggested above, this experiment may be used to illustrate three important processes:

1. The electrolytic refining of copper.
2. The quantitative determination of copper.
3. Copper plating.

Summary

Electrochemical experiments for high school students are discussed and very simple but satisfactory apparatus described. These experiments include the preparation of hydrogen, oxygen, chlorine, bromine, iodine and the deposition of copper. In the case of copper, the experimental work is made quantitative, and a crude verification of Faraday's Law is made. A method is presented for obtaining an oxygen-hydrogen mixture, which gives vivid detonating results.

FROM GALILEO TO COSMIC RAYS—A BOOK REVIEW

By Philip A. Constantinides
City College of Chicago, North Branch

From Galileo to Cosmic Rays, by Harvey Brace Lemon, Professor of Physics, The University of Chicago. Cloth. Pages xviii+450. 18.5×23 cm. 1934. The University of Chicago Press, 5750 Ellis Ave., Chicago, Ill. Trade edition (with stereoscope) $5.00, Educational Edition $3.75, stereoscope 75 cents extra.

Despite its rather unusual title, one does not get a real warning concerning the very unusual presentation of the material included in this recent addition to our scientific literature. The author in the opening paragraphs of his book, gives as his reason for this addition to so many other excellent books on physics, a need originating from the nature and scope of the survey courses offered at the University of Chicago and hopes that it will meet the interests of the adult reading public.

After reading numerous sections of the book and examining the plates and sketches that not only help to illustrate, but also to complement and embellish the text, we feel, not only that the author is over modest but that the reviewer on account of limitations of space will be handicapped in doing full justice to the book.

Professor Lemon, in his book, follows a more or less classical subdivision and arrangement. The book consists of six parts. Part I. (pp. 105—13 chapters) deals with most of the fundamental concepts and problems of the mechanics of solids, liquids, and gases. The discussion of the concept of energy and its various modes of manifestation form the dominant feature of the story of the first part. We believe that this section of the book is one of the most interesting both with respect to presentation and choice of material. The uninitiated reader in mechanics is taken through this part without the agonies that are so characteristic of standard college books of physics. Professor Lemon accomplishes this psychological effect by means of ingenious and in many respects novel devices. We insist on the term psychological effect since all the elements that ordinarily produce the agonies are there. Not a single major relation or equation is missing, in fact, additional relations and concepts are introduced by the incorporation in this part of the book, quite fittingly, the interrelations between work and heat. This effect is produced by the frequent and methodical alternation of topics of varying degrees of difficulty, the introduction of topics from related sciences, and the application of formulas to experiences of everyday life and to current scientific developments. This happy choice of subject material is integrated to a complete intellectual pleasure for the reader by the lucidity of presentation, the articulation and balancing of sentences, the choice of ordinary and stereoscopic pictures, and finally by the introduction of inimitable and bewildering sketches.*

Part II. (pp. 67—5 Chapters) deals with the phenomena of heat from the experimental standpoint and gives the interpretation of the kinetic theory of heat. Here we find such interesting chapters as the one on "Temperature of Various Places" where Michelson's experiment on the rigidity of the earth finds not only a simple presentation but for the first time its deserved place in a college physics text. In this part one also finds a genealogical table of a scientific theory.

Part III. (pp. 88—Chapters 9) on electricity and magnetism begins with the discussion of the electric and magnetic fields and their energies and then proceeds directly to fundamental electrodynamic relations and their industrial applications.

Part IV. (pp. 68—7 Chapters) begins with the conductivity of solids and liquids and the conduction of electricity through gases, and then the author introduces us to the work of J. J. Thompson, H. A. Wilson and R. A. Millikan. The work of the latter in connection with the determination of the electronic charge finds a beautiful and simple presentation. At this point we may remark that Professor Lemon does not hesitate to introduce and use Stoke's law both in connection with Millikan's work and the determination of terminal velocities. Other topics of modern physics such as photoelectric and thermionic effects, cathode rays, positive rays, radioactivity and transmutation find ample space.

Part V. (pp. 110—6 Chapters) is devoted to waves and radiation. Here the author offers an exposition of the classical theories of mechanical and electromagnetic wave propagation and their special attributes and proceeds to the discussion of laws of radiation and atomic structure concluding as the title of the book indicates with the problem of the nature and origin of cosmic rays.

Throughout the book the formulas are derived in easy methodical steps and especially in mechanics where the author accompanies every algebraic

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* The sketches are cleverly executed by Mrs. Chichi Lasley. We recommend especially the illustration on p. 258 confident that it will meet the approval of all men readers.

transformation with explanations as to the physical significance and implications of the transformation. The book does not include problems. We do not think that this is an advantage nor do we believe that the already overworked teachers should have the additional work of compiling and supplying their problems, yet we see an advantage in it since problems so selected will fit better the demands of a particular class. For another reason, not less important, we welcome the publication of this book with the hope that it together with similar publications in other fields will put to an end misunderstandings and fanciful interpretations concerning the nature and contents of the survey courses of the University of Chicago. Of late, other institutions in various parts of the country following the lead of the University of Chicago and Colgate University have introduced survey courses with distinct tendencies towards over-popularization and the vaudevillesque.

In this respect we have always believed that certain survey courses although intrinsically difficult, could be sufficiently humanized and diluted so as to arouse the interest of the average college student without degrading or vulgarizing the content of the course or the type of presentation. Professor Lemon's book crystallizes our ideas. The book is not a popularized text of physics, unless everything that arouses intense intellectual and artistic interest is to be classified as "popular." The book is too replete with facts, tables, and implications to justify this term. On the other hand, one is not lost in abstruse scientific theories and the nebulosities of the pulsating or expanding universe. The author's attitude in that respect can be best expressed in his own words, "The material is the solid substance of science, proved, checked, cross-checked. It is not the tenuous stratosphere of its speculations."

The book can be read by persons who are not familiar with the subject of physics by taking some pains with full confidence that these efforts will be fully rewarded. The teacher must read it with still greater attention lest he overlook some significant remarks in which the book abounds. Many teachers thoroughly tired of conventional textbooks of many unconnected topics and chapters will find this book as refreshing and welcome as a trade wind is to a sailor in the doldrums.

It is hoped that this book will find its place, not only in the bookshelves of teachers and libraries, but also in those of our intellectually alive adults.

SCIENCE QUESTIONS

December, 1934
Conducted by Franklin T. Jones

Please send copies of Tests and Examinations to Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Guild Question Raisers and Answerers—GQRA

Join by sending in a question or an answer. Pupils and classes are eligible. Send in your question now. Teachers!! Let your class propose a question or send in an answer.

TRIAL QUESTIONS AND THEIR ANSWERS

Teachers in all science subjects—physics, chemistry, biology, geography, etc., are requested also to send in their "trial questions."

The questions in 643 "failed too many pupils." Why? They are republished below a few at a time, separately numbered. Please try them on your pupils and send in a good answer from each class; together, if possible, with the number of satisfactory and unsatisfactory answers. Comment is desired. What do your pupils say about them?

654. 1. When a body displaces less than its own weight of liquid will it sink or float?

655. 2. A 10-horsepower engine will do how much work in a minute?

656. 3. Will an object weigh more or less in a vacuum than in air?

657. 4. When a clock loses time should its pendulum be lengthened or shortened?

658. 5. What is the mechanical advantage of a single movable pulley?

ANSWERS FROM THE PHILLIPPINES

By Miss Luz A. Santos (elected to GQRA, No. 43) and members of her Physics Class, Rizal High School, Pasig, Rizal, P.I.

This is from far-off Philippine Islands in response to your TRIAL QUESTIONS appearing in SCHOOL SCIENCE AND MATHEMATICS (May, 1934). I gave the questions to my physics classes and here are the numbers of satisfactory and unsatisfactory answers for each:

654— 72	satisfactory;	45	unsatisfactory
655— 96	"	21	"
656— 64	"	53	"
657—114	"	3	"
658—109	"	8	"

I am enclosing some good answers from each of my three classes, and also a copy of a mimeographed test for our second grading period.

Answer by Santos Dalida (GQRA No. 44)
Rizal High School, Pasig, Rizal, P.I.

654. If a body displaces less than its weight of a liquid, will it sink or float?

Answer: The body will sink, because the weight of the body is greater than the weight of the water displaced. In reference to this, Archimedes' principle states that the floating body must displace its own weight of the liquid in which it floats. Since the body displaces less therefore, the body will sink.

Answer by Primitiva Rodriguez (GQRA, No. 45)
Rizal High School, Pasig, Rizal, P.I.

655. A 10 H.P. engine can do how much work in 1 minute?

Answer.—A 1 H.P. engine can do 33,000 ft. lbs. of work a minute. Therefore, 33,000 ft. lbs./minute $\times 10 = 330{,}000$ ft. lbs. per minute.

TO THE EDITOR: *Here are two answers to question 656, which have caused much debate in my class. The two boys who are sending their answers disagree with the statements made in sec. 91 of Black and Davis, New Practical Physics (1932) as an answer to question 656.*

Will any member of GQRA make the answer clearer to them? LUZ A. SANTOS.

Answer by Hector San Miguel, (GQRA, No. 46)
Rizal High School, Pasig, Rizal, P.I.

656—Will a body weigh more or less in a vacuum than in air?

Answer: It will weigh the same in a vacuum as in air because the mass of a certain body remains the same anywhere we take it. Besides if no force tends to buoy up a body when in a vacuum, there is also no force to press the body downward. The same case as in the air. If a body is buoyed up as shown by the resistance of the air upon a falling body, there is also a force tending to press it downward. Therefore the buoyant force is counteracted by the air pressure. These lead to the conclusion that the body weighs the same in both cases.

Answer by Eustino R. Francisco (GQRA, No. 47)
Rizal High School, Pasig, Rizal, P.I.

656. Will a body weigh more or less in air than in a vacuum.

Answer: The body will weigh the same in air as in a vacuum because if the weight in air be considered less than in a vacuum, Newton's law of the weight of a body will be false. The law states that the weight of a body in the universe is the resultant of the gravitational attraction and the centrifugal force of the earth and not at all in connection with air displacement or anything else.

If it would be reasoned out that the body displaces an amount of air which made its weight lighter, it may also be reasoned out that its displacement is small in comparison with the total air pressure with which it is subjected. What makes the water rise in suction pump is the question? If it is air pressure therefore your air displacement talking about is useless in comparison with the press of air above it. Besides divers under the column of air in the universe and water when the pressure to which he is subject is computed the air pressure is added not subtracted due to its displacement.

Lastly as stated in Millikan and Gale "New Practical Physics" "At a given depth a liquid presses downward, upward, and sidewise at exactly the same force." As air and liquids in Archimedes principles is considered as fluids air is also like water in displacement, in pressure and in force so the forces acting are also equal.

Answer by Primitiva Rodriguez, (GQRA, No. 45)

657. If a clock loses time, must a pendulum be shortened or lengthened?

Answer: The pendulum must be shortened. Because the shorter the cord of a pendulum, the faster it vibrates.

Answer by Santos Dalida, GQRA, No. 44

658. What is the M. A. of a single movable pulley?

Answer: The M. A. of a single movable pulley is 2. Because there are two supporting strands.

GENERAL SCIENCE TEST

Proposed by J. W. Galbreath, (Elected to GQRA, No. 42) Lansdowne Junior High School, East St. Louis, Ill.

680. What results do other teachers get with this same test? (Please answer through SCIENCE QUESTIONS DEPT.).

DEAR MR. JONES:

I am sending you a General Science test which I have used successfully for about two and a half years in my classes.

The questions are graded as to increasing difficulty in each of the three parts.

I have used the test at the beginning of the 9–2 (last half or last semester of 9th grade work) also at the end of the 9th grade as a semester examination, usually a part four was given also, consisting of thought questions which called for the essay type of answer. In this case part four counted 25 points and each of the parts here 25 points each, making a total of 100 possible points.

The test has been given to 424 9th grade pupils.

On the three parts, 75 points is perfect, the highest score at the end of the 9th grade or for the 9–2 pupils was 65, lowest 32, medium 48.

Highest score at the beginning of last semester or 9–2 work was 60, lowest 27, medium 42. The average gain per average student was from 5 to 6 points for the semester.

This examination is in three parts. Each part counts 25 points.

Read the question or statement carefully before answering. Interpretation of the question is part of the examination. You will have about *40 Minutes* for the test.

PART I

(Mark the true statements with a + sign and the false with a − sign)

1. In case of suffocation from being in a burning building or by drowning artificial respiration should be administered and a doctor called immediately.
2. Cooking improves the digestibility of most foods.
3. Water may be changed to water vapor by boiling the water.
4. Emergency treatment for burns may be given by applying some thick paste, such as vaseline or olive oil, to exclude the air from the burned parts.
5. If a coil of wire is rotated in a magnetic field, a current of electricity will flow in the wire.
6. If an entire community is suffering from an epidemic of typhoid fever, it is likely that the water supply is the source of the disease.
7. When a volume of saturated air is cooled, a part of the water vapor condenses.
8. A balanced diet is the most common cause of indigestion.
9. The habitual use of alcohol increases one's efficiency but lowers his speed.
10. The cutting of a great number of trees near the source of a river and along its tributaries, might cause floods near the mouth of the river.
11. The more water vapor there is in the air, the less likely it is to rain.
12. If water vapor in the air is condensed at a temperature below freezing it is likely to rain.
13. One of the earth's chief source of energy is the earth.
14. Vaccination against Small Pox makes one immune to many other diseases.
15. Germs multiply so slowly that disease is not usually caused for several months after the germs enter the body.
16. A part of the carbon which is now in the air may sometime form a part of some tree or plant which may eventually form some kind of fuel containing the original carbon of the air.

17. All bacteria are harmful to mankind.
18. The construction of an electric motor is very similar to that of a generator.
19. A clay soil is usually very poor for gardens.
20. Electric lights are operated by static or frictional electricity.
21. If the constellation of stars known as Cassiopeia, or the Queen in Her Chair, is directly beneath the North Star, the Big Dipper will also be beneath the North Star.
22. In silver plating with electricity it is necessary that articles to be plated be placed in a copper solution.
23. The most economical use of heat energy is through the gas engine.
24. The kerosene rises in the wick of a lamp because of atmospheric pressure.
25. That part of an individual's food that has not been digested when it leaves the stomach may be digested in the intestines.

PART II

Complete the following statements:

1. Temperature is measured by a ____________
2. Air pressure is measured by a ____________
3. A hot, dry wind will evaporate water from the earth's surface much more____________than will a moist, cool wind.
4. Mars, Jupiter, and Uranus are names of____________
5. The moon gets its light from the____________
6. The Big Dipper is a____________
7. What kind of iron comes from the blast furnace?____________
8. What gas do animals throw off through the lungs?____________
9. If____________poles of magnets are brought near each other, there will be a strong attraction between the poles.
10. If the period of the earth's revolution about the sun were to increase, the length of our seasons would____________
11. The seasons are caused by____________
12. The radio sends its messages through space by____________
13. If the moon should come directly between the sun and the earth there would be an____________
14. The food which is taken into the body is changed to a liquid form by the process of____________
15. Most of soil on the earth was probably formed by____________
16. If a direct current of electricity is allowed to flow through a coil of insulated wire which is wrapped around a soft iron core the iron becomes____________
17. If one hears thunder from a flash of lightning five seconds after he sees the flash, the lightning is approximately________miles away.
18. The boiling point of water is ______F at sea level.
19. If a person were at zero latitude he would be on the____________
20. Most of our winds come from the____________
21. The force of exploding gas supplies the power to run the____________
22. When one gets all of his teeth he should have____________
23. If a substance has a specific gravity of more than________the substance will________in the water.
24. When the wind sets in from points between south and southwest and the barometer falls steadily, ____________weather is approaching from the____________
25. Messages are transmitted over the telephone wires by ____________

PART III

Select the word or statement given after each incomplete sentence that makes it true. Write the number (not the word itself) of the word that names the truest answer.

1. A compass is used to tell (1) time, (2) temperature, (3) altitude, (4) distance, (5) direction.
2. A healthy blossom develops into (1) thorns, (2) leaves, (3) fruit, (4) bark, (5) limbs.
3. Most of our common plants start from (1)roots, (2) cuttings, (3) seeds, (4) grafts, (5) buds.
4. Water enters a plant through the (1) leaves, (2) trunk, (3) roots, (4) branches, (5) buds.
5. A boat sinks in water until the water displaced equals the weight of the (1) boat, (2) water, (3) air, (4) people, (5) freight.
6. Most diseases enter the body through the (1) ears, (2) feet, (3) hands, (4) mouth, (5) eyes.
7. The name of the large nerve leading from the eye is (1) styptic, (2) auditory, (3) optic, (4) olfactory, (5) facial.
8. The following substance is commonly used for insulating electric conductors, (1) copper, (2) zinc, (3) steel, (4) rubber, (5) wet cloth.
9. The part of the steam engine in which the piston moves is the (1) steam chest, (2) valve gear, (3) cylinder, (4) slide valve, (5) bell.
10. The tilt or slant of the earth's axis causes the (1) seasons, (2) years, (3) storms, (4) day, (5) night.
11. The instrument used to raise or lower the voltage of an alternating current is (1) motor, (2) voltmeter, (3) transformer, (4) electromagnet, (5) voltaic cell.
12. The inventor of the telescope was (1) Aristotle, (2) Copernicus, (3) Newton, (4) Galileo, (5) Kepler.
13. The name given the revolving electro-magnet in the electric motor is (1) commutator, (2) armature, (3) coil, (4) battery, (5) field magnet.
14. A boat which will not tip over is said to have (1) gravity (2) weight, (3) stability, (4) buoyance, (5) lightness.
15. The chronometer is a (1) boat, (2) submarine, (3) compass, (4) clock, (5) sextant.
16. A molecule of water contains more than one kind of (1) compounds, (2) base, (3) acid, (4) atoms, (5) mixture.
17. The electrical unit of resistance is the (1) ohm, (2) relay, (3) ton, (4) ampere, (5) volt.
18. Plants manufacture food in their (1) roots, (2) leaves, (3) stems, (4) flowers, (5) stomata.
19. How many years do biennial plants live? (1) 1, (2) 2, (3) 3, (4) 4, (5) 5.
20. The gas in an engine explodes in the (1) carburetor, (2) cylinder, (3) generator, (4) crank case, (5) transmission.
21. Your thinking center is (1) cerebrum, (2) medulla, (3) pons, (4) cerebellum, (5) arbor vitae.
22. In the dry cell the positive pole is made of (1) zinc, (2) graphite, (3) magnesium dioxide, (4) copper, (5) carbon.
23. Humus is largely made up of decayed (1) plants, (2) animals, (3) rocks, (4) minerals, (5) ores.
24. The inventor of the submarine was (1) Stephens, (2) Henry, (3) Faraday, (4) Holland, (5) Watt.
25. Heat is measured in (1) calories, (2) pounds, (3) gallons, (4) feet, (5) meters.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

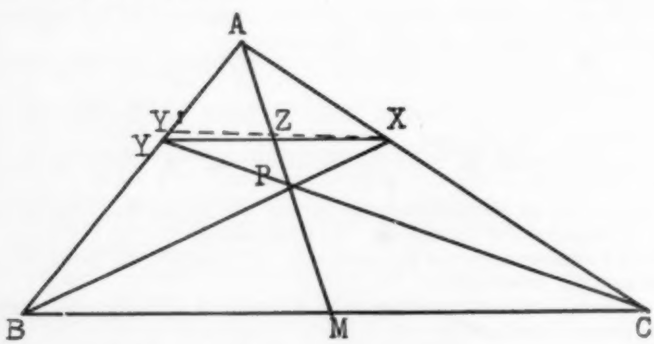
3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTION

1340. *Roy MacKay, Albuquerque, New Mexico.*

1346. *Proposed by T. A. Pickett, Boston, Mass.*

Lines drawn from the extremities of the base of a triangle intersecting on the median to the base, cut the opposite sides at points which determine a line parallel to the base.



Solution by Roy MacKay, Portales, New Mexico

Let P be any point in the median AM of the triangle ABC. Suppose BP cuts AC in X and CP cuts AB in Y. In order to prove XY is parallel to BC, consider XY' a line through X parallel to BC which cuts AM in Z and AB in Y'. Join $Y'P$. From the similar triangles formed by the parallels

XY' and BC, $Y'Z/\frac{1}{2}BC=AZ/AM=XZ/\frac{1}{2}BC=PX/PB=ZP/PM$. Therefore $Y'Z/MC=ZP/PM$; and since angles $Y'ZP$ and PMC are equal, triangles $Y'ZP$ and CMP are similar. Hence angles $Y'PZ$ and CPM are equal and CPY' is a straight line. Therefore Y and Y' coincide and XY is parallel to BC.

Solutions also submitted by Maxwell Reade, Brooklyn, W. E. Buker, Leetsdale, Pa., Claude Shannon, University of Michigan, and the proposer.

Note. Charles W. Trigg and J. E. Tuer offer very simple solutions by the use of Ceva's Theorem.

1347. *Proposed by the Editor.*

If the sides of a quadrilateral are a, b, c, d, and if a pair of opposite angles are A and C, prove that:

$$(\text{Area})^2=(s-a)(s-b)(s-c)(s-d)-abcd\cos^2\frac{A+C}{2},$$

where $2s$ is the sum of the sides.

Solution by Charles W. Trigg, Los Angeles, Calif.

In the quadrilateral $ABCD$, let $AB=b$, $BC=c$, $CD=d$, and $DA=a$. Since $2s=a+b+c+d$,

$$(s-a)(s-b)(s-c)(s-d)=\frac{(b+c+d-a)}{2}\cdot\frac{(a-b+c+d)}{2}\cdot\frac{(a+b-c+d)}{2}\cdot\frac{(a+b+c-d)}{2}.$$

$$\begin{aligned}(1)\qquad 16(s-a)(s-b)(s-c)(s-d)&=2(a^2b^2+a^2c^2+a^2d^2+b^2c^2+b^2d^2+c^2d^2)\\&\quad-(a^4+b^4+c^4+d^4)+8abcd.\end{aligned}$$

From the two expressions for the square of the diagonal BD,

$$a^2+b^2-2ab\cos A=c^2+d^2-2cd\cos C.$$
$$a^2+b^2-c^2-d^2=2(ab\cos A-cd\cos C).$$

Squaring,

$$\begin{aligned}&a^4+b^4+c^4+d^4+2(a^2b^2-a^2c^2-a^2d^2-b^2c^2-b^2d^2+c^2d^2)\\&\quad=4(a^2b^2\cos^2 A+c^2d^2\cos^2 C-2abcd\cos A\cos C).\end{aligned}$$

Rearranging,

$$\begin{aligned}4[a^2b^2(1-\cos^2 A)+c^2d^2(1-\cos^2 C)]&=2(a^2b^2+a^2c^2+a^2d^2+b^2c^2\\&\quad+b^2d^2+c^2d^2)-(a^4+b^4+c^4+d^4)+8abcd-8abcd\\&\quad-8abcd\cos A\cos C.\end{aligned}$$

Substituting from (1),

$$\begin{aligned}(2)\qquad 4a^2b^2\sin^2 A+4c^2d^2\sin^2 C&=16(s-a)(s-b)(s-c)(s-d)\\&\quad-8abcd(1+\cos A\cos C).\end{aligned}$$

$$\text{Area}=\triangle ABD+\triangle BCD=\tfrac{1}{2}ab\sin A+\tfrac{1}{2}cd\sin C.$$

Squaring and multiplying by 16,

$$16\,(\text{Area})^2=4a^2b^2\sin^2 A+4c^2d^2\sin^2 C+8abcd\sin A\sin C.$$

Substituting from (2) and grouping,

$$16\,(\text{Area})^2=16(s-a)(s-b)(s-c)(s-d)-16abcd\,\frac{1+\cos A\cos C-\sin A\sin C}{2}.$$

$$(\text{Area})^2=(s-a)(s-b)(s-c)(s-d)-abcd\,\frac{1+\cos(A+C)}{2}.$$

$$(\text{Area})^2=(s-a)(s-b)(s-c)(s-d)-abcd\cos^2\frac{A+C}{2}.$$

A solution also submitted by Maxwell Reade, Brooklyn, N.Y.

1348. *Proposed by Norman Anning, University of Michigan.*

Given that $b=\sqrt{2-\sqrt{2+a}}$ and that a is an approximation to the value of 2 sin 18°, prove that b is a better approximation.

Solution by the proposer

Let $a=2\sin(18°+x)$
$=2\cos(72°-x)$.
$\sqrt{2+a}=2\cos(36°-x/2)$
$b=\sqrt{2-2\cos(36°-x/2)}=2\sin(18°-x/4)$ and the last angle is nearer to 18° than is the first.

Also solved by Claude Shannon, University of Michigan.

1349. *Proposed by P. H. Nygaard, Spokane, Wash.*

$$\begin{array}{r} ec)\overline{cbege}(cdg \\ \underline{bkd} \\ hdg \\ \underline{hkh} \\ kde \\ \underline{kde} \end{array}$$

The above is a long division problem in which the digits have been replaced by letters. Each letter, wherever found, represents the same digit. Each digit, wherever found, is represented by the same letter. Determine which digit each letter represents, using a method which will show that no other solution is possible.

Solution by W. E. Buker, Leetsdale, Pa.

(1) $c\times ec=bkd;\ c-b=1.$

The only values of b, c, e, d, k satisfying these conditions are

b	c	e	d	k
3	4	9	6	7
2	3	8	9	4
2	3	7	9	1
1	2	8	4	6
1	2	9	4	8

(2) $d\times ec=hkh.$

Condition (2) eliminates all possibilities under (1) except the numbers of the second row. The remainder of the unknowns are found immediately. We have $b=2$, $c=3$, $d=9$, $e=8$, $g=6$, $h=7$, $k=4$. and hence the solution is $32868\div 83=396$.

Also solved by Charles W. Trigg, Los Angeles; Aaron Buchman, Buffalo, N. Y.; Craig L. Smith, Missoula, Mont.; Anice Seybold, Monticello, Ill.; Hugh L. Deinmer, Custer, South Dak.; J. E. Tuer, Ontario, Canada; Claude Shannon, University of Michigan and the proposer.

1350. *Proposed by Charles P. Louthan, Columbus, Ohio.*

A train dispatcher sends out three trains at h-hour intervals on parallel tracks. Each train travels at a uniform rate of speed from the starting point to the end of the trip, and all three reach the end of the line at the same time.

When the fastest of these trains has traveled one half of the time required to reach its destination, it is separated from the other two by distances of b and a miles respectively.

How far is the terminal from the starting point?

Solution by J. E. Tuer, Orillia, Ontario

Let m= distance between stations and x, $x+h$, $x+2h$ be the time required for the trains.

When the fast train has travelled $x/2$ hours, the slow one has travelled $\left(\frac{4h+x}{2}\right)\left(\frac{m}{x+2h}\right)$ miles, and the second one $\left(\frac{2h+x}{2}\right)\left(\frac{m}{x+h}\right)$ miles while the fast train has travelled $m/2$ miles.

Hence, from the conditions of the problem

$$\left(\frac{4h+x}{2}\right)\left(\frac{m}{x+2h}\right)-\frac{m}{2}=b \tag{1}$$

$$\left(\frac{2h+x}{2}\right)\left(\frac{m}{x+h}\right)-\frac{m}{2}=a. \tag{2}$$

Clearing of fractions and collecting terms,

$$2h(m-2b)=2bx \tag{3}$$

$$h(m-2a)=2ax. \tag{4}$$

Dividing (3) by (4) and solving for x,

$$x=\frac{2ab}{2a-b}.$$

Solutions also submitted by Charles W. Trigg, Los Angeles, Craig L. Smith, Missoula, Mont.; Claude Shannon, University of Michigan, W. E. Buker, Leetsdale, Pa.; Maxwell Reade and the proposer.

1351. *Proposed by Cecil B. Read, Wichita, Kan.*

Given any four points, A, B, C, D in order on a straight line. Circles are described on the segments AC and BD as diameters, intersecting at P. Lines PA, PB, PC, PD are drawn. Prove that the angle BPC is complementary to one half the angle of intersection of the circles.

Solution by Claude Shannon, University of Michigan

Let E and F be the centers, and PM and PN the tangents at the point P to the circles drawn on AC and BD respectively. Let θ be the angle between the circles, i.e. $\theta=180°-\angle NPM$.

Then $\angle EPF=\theta$, since their sides are perpendicular, right to right and left to left.

(1) $\theta=180°-(\angle PEF+\angle PFE)$. Also

(2) $\theta=180°-\angle MPC-\angle CPB-\angle BPN$.

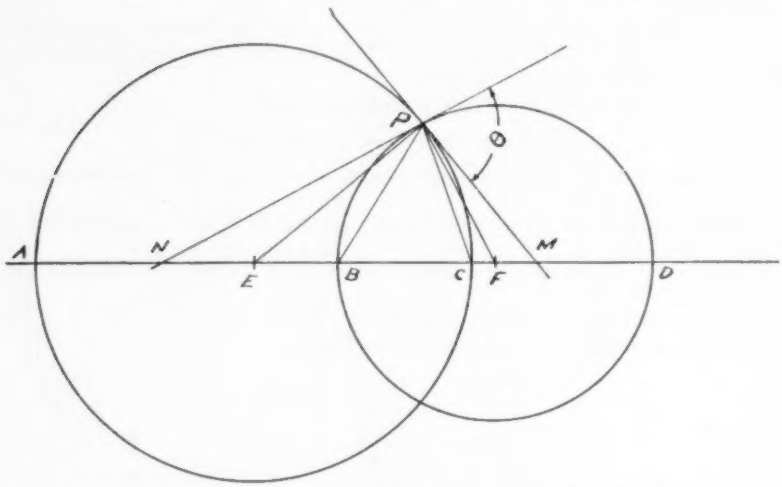
(3) Since $\angle MPC \sim \frac{1}{2}\angle PEF$ and $\angle BPN \sim \frac{1}{2}\angle PFB$

(4) $\theta=180°-\angle CPB-\frac{1}{2}\angle PEF-\frac{1}{2}\angle PFB$

and by substitution from (1) and (3) in (4)

$$\theta = 180° - \angle CPB - \tfrac{1}{2}(180° - \theta). \text{ Hence}$$

$$\theta/2 = 90° - \angle CPB. \text{ Hence } \angle CPB \text{ and } \theta/2 \text{ are complementary.}$$



Solutions also submitted by W. E. Buker, Leetsdale, Pa., Maxwell Reade, Brooklyn, Samuel H. Barkan, Brooklyn and the proposer.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problem ssubmitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1316. H. Hansen Smith, Battle Creek, Iowa.

PROBLEMS FOR SOLUTION

1364. *Proposed by Benjamin Braverman, Brooklyn, N. Y.*

In any inscribed quadrilateral the product of the diagonals equals the sum of the products of the opposite sides.

1365. *Proposed by E. S. Loomis, Cleveland, Ohio.*

A man having \$400 purchased 100 animals giving \$8 a head for hogs, \$2 for sheep, \$1 for lambs, and \$9 for calves. In how many different ways can he purchase the 100 animals.

1366. *Proposed by Norman Anning, University of Michigan.*

Show that the decimal fraction equivalent to the sum of the infinite series $1/10+2/100+3/1000+\cdots$ does not contain 8.

1367. *Proposed by the Solid Geometry Class, Centralia (Ill.) Township High School.*

If a cube C can be divided into equal sub cubes, the ratio of the number of sub cubes having no faces and those having three faces in surface of C, is equal to the cube of the ratio of the number of sub cubes having one face and those having two faces in the surface of C.

1368. *Proposed by Dewey C. Duncan, University of California.*

Show that, for just one real value of a, the equation $ax^4+(x-1)^3=0$ has a double root. Find the value of a and the roots of the equation.

1369. *Proposed by Hugh L. Demmer, Custer, S. Dakota.*

(a) A plumber wishes to erect piping from the lower corner to the opposite upper corner of a room 20 feet long, 15 feet wide, and 10 feet high. The piping is to be laid along the walls, floor or ceiling. What is the shortest length of piping necessary?

(b) Assuming a general case of the above problem, with $h<w<l$, should the piping be laid along (1) floor and side wall, (2) floor and end wall, or (3) side wall and end wall, in order to use the shortest length of piping? Prove.

Error in statement of problem 1361. Replace the word "can" in the first sentence by the word "cannot".

BOOKS AND PAMPHLETS RECEIVED

Exploring With the Microscope, by Raymond F. Yates, Author of "Boys' Book of Model Boats" and "The Complete Radio Book." Cloth. Pages xv+182. 125 × 19 cm. 1934. D. Appleton-Century Company, 35 West 32nd Street, New York. Price $2.00.

Handbook of Chemistry and Physics. Editor-in-Chief, Charles D. Hodgman, Associate Professor of Physics at Case School of Applied Science. 19th Edition. Cloth. 1933 pages. 10.5 × 17 cm. 1934. Published by Chemical Rubber Publishing Company, Cleveland, Ohio. Price $6.00.

Solid Geometry, by Elizabeth Buchanan Cowley, Teacher of Mathematics Allegheny Senior High School, Pittsburgh, Pa. Cloth. Pages ix+230. 12.5 × 18.5 cm. 1934. Silver Burdett and Company, 39 Division Street, Newark, New Jersey. Price $1.28.

From Galileo to Cosmic Rays, by Harvey Brace Lemon, Professor of Physics, The University of Chicago. Photographs by the Author and Drawings by Chichi Lasley. Cloth. Pages xviii+450. 18.5 × 23 cm. 1934. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $3.75. With Stereoscope 75 cents extra.

The Teaching of Arithmetic, by Paul Klapper, Dean of the School of Education, College of the City of New York. Cloth. Pages xiii+525. 13 × 20 cm. 1934. D. Appleton-Century Company, 35 West 32nd Street, New York. Price $2.60.

Atomic Physics, by Members of the Physics Staff of the University of Pittsburgh: Professors Oswald H. Blackwood, Elmer Hutchisson, Thomas H. Osgood, Arthur E. Ruark, Wilfred N. St. Peter, George A. Scott, and Archie G. Worthing. Cloth. Pages vi+348. 14.5 × 23 cm. 1933. John Wiley and Sons, Inc., New York. Price $3.50.

Science in the New Education, by S. R. Slavson, Formerly Director, Science and Manual Arts Departments, The Walden School, New York; Research Director, Malting House School, Cambridge, England, and Robert K. Speer, Professor of Education, and Chairman, Elementary Education Department, School of Education, New York University. Cloth. Pages xii+396. 13.5 × 20.5 cm. 1934. Prentice-Hall, Inc., 70 Fifth Avenue, New York. Price $2.50.

Science at Home, by Edith M. Patch and Harrison E. Howe. Cloth. Pages xiv+450. 14 × 18.5 cm. 1934. The Macmillan Company, 60 Fifth Avenue, New York. Price 92 cents.

Astronomy, by John Charles Duncan, Professor of Astronomy in Wellesley College. Second Edition Revised. Illustrated. Cloth. Pages xix+435. 14 × 21.5 cm. 1930. Harper and Brothers, 49 East 33rd Street, New York.

Radio as a Cultural Force, by William S. Paley, President, The Columbia Broadcasting System. Paper. 29 pages. 11.5 × 18 cm. The Columbia Broadcasting System, 485 Madison Avenue, New York City.

The High School Science Library for 1933–1934, by Professor Hanor A. Webb, Editor of Current Science, George Peabody College for Teachers, Nashville, Tennessee. Reprinted from Peabody Journal of Education, Vol. 12, No. 2, September, 1934. 12 pages. 16.5 × 24 cm.

Short Wave Radio Handbook, by Clifford E. Denton. Paper. 127 pages. 16 × 21.5 cm. Radio and Technical Publishing Company, 45 Astor Place, New York City.

Report of Conference on Supervised Correspondence Study, by Frank W. Cyr, Chairman of the Conference and Assistant Professor of Education, Teachers College, Columbia University, New York. Paper. 66 pages. 15 × 23 cm. International Textbook Company, Scranton, Pa. Price 25 cents.

The Development of Social Intelligence Through Part-Time Education, by Irvin S. Noall, Chairman, State Supervisor of Industrial Education, Salt Lake City, Utah. Paper. Pages ix+67. 14.5 × 23 cm. 1934. Superintendent of Documents, Washington, D. C. Price 10 cents.

BOOK REVIEWS

The Physical Basis of Things, by John A. Eldridge, Professor of Physics, University of Iowa. First Edition. Cloth. Pages xiv+407. 14.5×23 cm. 1934. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York. Price $3.75.

This is one of a number of excellent books that have recently appeared on the subject of modern physics. In the preface the author states that it has been prepared for use as a text for pupils who have had a course in general physics and that it is within the grasp of the average sophomore who has given a year to the serious study of physics. If this proves to be true the author has made a real contribution, for every student of the subject is anxious to know about the methods and results of current research.

The first forty pages contain a discussion of relativity, but the author

admits that a real grasp of the subject cannot be obtained from so limited a treatment. Nevertheless, it is an excellent summary and will inspire many students to further study. Following this is a section of over one hundred pages on kinetic theory which will surely measure up to the aim set, especially if the student has had some work in chemistry, even if only a good secondary school course. The remainder of the book is much more difficult because the student has been kept so busy in his first year with classical mechanics and the fundamentals of wave motion, electricity, and geometrical optics that he has had little time to form much of an acquaintance with radiation, spectral series, X-rays, and crystal lattices. It is doubtful if the average sophomore will have sufficient background to digest this, the real meat of this text. With a select group and a skillful instructor this book should prove a most useful guide. The language is as simple as it can be made; the illustrations are excellent; and the author's enthusiasm for and grasp of the subject are inspiring. By use of the excellent selection of references for collateral reading listed by chapters in the back of the book it should accomplish its aim in the hands of superior students.

G. W. W.

Handbook of Chemistry and Physics. Editor-in-Chief, Charles D. Hodgman, Associate Professor of Physics at Case School of Applied Science. 19th Edition. Cloth. 1933 pages. 10.5×17 cm. 1934. Published by Chemical Rubber Publishing Company, Cleveland, Ohio. Price $6.00.

The Handbook is so well known that a review is unnecessary except to point out the changes and additions. The most noticeable feature of the 19th edition is its division into five major sections: (1) Mathematical Tables 278 pages, (2) Properties and Physical Constants 485 pages, (3) General Chemical Tables, Specific Gravity and Properties of Matter 392 pages, (4) Heat and Hygrometry, Sound, Electricity and Magnetism, Light 425 pages, (5) Quantities and Units, Miscellaneous Tables 324 pages. Each section is set off by stiff yellow paper on which is printed a list of the tables included in that section. This feature is a great convenience since the book has now grown to a volume of nearly 2000 pages.

Approximately one hundred pages of new tables have been added, the largest being forty-three pages of X-ray Crystallographic data. This subject has become so important that these data are invaluable in the study of science. Other additions include Density of Moist Air, Thermodynamic Properties, Logarithms of Trigonometric Functions for Decimal Fractions of a Degree, Natural Functions for Angles in Radians, Flame Spectra, Fusing Currents for Wires, etc., etc. Many tables in the 18th and previous editions have been revised and enlarged. So thorough and inclusive has the *Handbook* now become that it is almost safe to say of any question concerning known properties of matter, constants, or tables for making computations in ordinary science study and research "You will find it in the *Handbook.*"

G. W. W.

The Collared Lizard, A Laboratory Guide by D. Dwight Davis, Assistant, Department of Zoology, Field Museum of Natural History, Chicago, Ill. Cloth. Pages viii+57. 12.5×19 cm. 1934. The Macmillan Company, 60 Fifth Avenue, New York. Price 90 cents.

This laboratory guide is the latest addition to the growing list of dissection manuals for the study of vertebrate zoology. The study of the reptiles as members of the vertebrates is limited, in most courses of comparative anatomy, to a few dissections on the turtle, one of the most

specialized of all the reptiles, while more generalized forms remain unnoticed. Since the lizards are much less specialized than other present day reptiles this guide should prove to be a valuable addition to courses in vertebrate zoology, where the fundamentals of reptilian structure have been rather neglected because of the lack of adequate guides and material. The style of the book follows rather closely others of the series. Each system is considered separately and full directions are given for the dissection of each principle organ system. Suggestions for laboratory drawings are included with the directions.

J. F. Schuett

A Textbook of General Botany for Colleges and Universities, by Richard M. Holman, Associate Professor of Botany, University of California, and Wilfred W. Robbins, Professor of Botany, University of California. Third Edition, Size $6'' \times 9''$, pages xiii+626 with 462 illustrations. John Wily and Sons, Inc., N.Y., 1934, cost $4.00.

This is an exceptionally fine piece of work in every way. Paper, print, illustrations are all of the finest quality. The first Edition was printed in 1924, thus three editions have been prepared in the ensuing ten years, which speaks well for the watchfulness of the authors in keeping the book up-to-date. Each edition was rewritten, not just revised textually.

The illustrations are numerous, clear and well labelled with unusually full explanations of the figure. The text is simple and clear, easily understood. The reader or student may never be uncertain about its meaning. The field covered by the text is the usual survey of the plant body in all its relations including the relation of the plant to its environment and in part II a survey of the plant kingdon concluding with a chapter on Evolution and heredity. There is an appendix of references and suggestions for collateral reading.

We cannot commend this book too highly for college and university uses as well as for a reference book for secondary school teachers who wish to broaden their vision of their work and keep up-to-date with the results of research studies of plants in this field.

W. Whitney

Review of Pre-College Mathematics, by C. J. Lapp, Professor of Physics, F. B. Knight, Professor of Educational Psychology, and H. L. Rietz, Professor of Mathematics, all at the University of Iowa. Paper. 124 pages. 21×27 cm. 1934. Scott, Foresman and Company, 623 South Wabash Avenue, Chicago, Ill.

In introducing this book the authors say: "Pre-College Mathematics is a work-book providing explanations of—and drill in—the fundamentals of arithmetic, algebra, geometry, and trigonometry, with the major emphasis on algebra." They suggest three specific uses for the work-book: (1) Supplementary material for first-year college courses in mathematics. (2) Preparation for college courses in physics or chemistry. (3) General review for high school seniors. The selection of review and drill material is excellent as a preparation for college work. Many failures in college physical science are due to insufficient mathematical experience and skill. Special classes of high school seniors who are planning to go to college could profitably make use of this text either for regular class work or as an extra curricular activity.

G. W. W.

What a man knows should find expression in what he does. The value of superior knowledge is chiefly in that it leads to performing manhood. *C. N. Bonce.*

AMERICAN OPTICAL APPARATUS NOW SUPERIOR

American optical engineers no longer look to Europe for leadership in the field of optics, according to members of the American Optical Society who attended the annual meeting of that body at the Bureau of Standards on October 18th and 20th.

The World War found the Allies scurrying around in the effort to supply the armies with effective field glasses and fire-control instruments. The United States realized the nature of this critical situation and in March 1917, a small group of men were called together at Washington to discuss the outlook. Members of the general staff of the Army, a few officials of government bureaus and a number of scientific men comprised this group.

They found conditions of warfare wholly changed since the Civil War. The objectives of heavy gun-fire were never in plain view. Ranges had increased to ten or twelve miles. Unless extreme precision could be attained such effort must be obviously wasted. Optical instruments meant optical glass, and optical glass is by far the most refined product of the glass-makers' art.

A canvass was immediately instituted by the Naval Consulting Board, by the General Munitions Board and the National Research Council. They found that most of the optical glass had heretofore been imported; that stocks were exhausted; and that the secrets of making fine optical glass were mainly locked up in one optical plant abroad. One encouraging evidence of forethought, however, came to light.

As early as 1912, William Bausch of Bausch & Lomb had recognized as a matter of business expediency that an optical industry in the United States could not safely depend for its most indispensable raw material upon foreign sources alone. He had therefore experimented with several small glass plants. By 1917, certain glasses could be dependably made, but the total capacity of the plant was no more than 2,000 pounds per month, while the need amounted to 2,000 pounds a day.

For the optical instruments required by the government to control gun-fire on the sea and at the front, nine different varieties of optical glass were necessary, and but two of them had ever been successfully made in this country. The seven others were shrouded in mystery.

To meet this situation the government called in scientists with some knowledge of silicate chemistry. Two groups were formed, one from the Carnegie Geophysical Laboratory in Washington associated itself with Bausch & Lomb, in an effort to extend and perfect its output. The other group, from the Bureau of Standards, was to operate in part in its own Pittsburgh laboratory, and in part with the Charleroi plant of the Pittsburgh Plate Glass Company. To each of these groups of collaborators was assigned the task of providing one half of the requirements of both army and navy in the shortest possible time. At the end of four months Bausch & Lomb was successfully producing all of the varieties of glass necessary and had multiplied its output four times. Of the 650,000 pounds of optical glass made for the Army and Navy during the war, 450,000 pounds were made under the personal direction of Edward and William Bausch.

The great exhibit of instruments at the Bureau of Standards in October and the talks by physicists, chemists and optical designers, showed the scope and variety of research work done in the field of optics since the War. The evidence was plentiful that not only has the United States achieved independence of all European sources, but it has acquired many secrets of its own which now rank American products as the finest in the world. The varieties of glass on display, the number of uses indicated and

the proofs of precision workmanship were shown in the astronomical exhibit, the military instrument display and in the numerous exact instruments for the analyzation of metals, chemicals, textiles, colors, paper and food. Opthalmic instruments were impressive in number and uses. Hardly an industry or a science was omitted from the list of uses to which these instruments applied.

A NEW DEAL IN EDUCATIONAL MEASUREMENT

It has been a long while since anything radically new in tests and measurements has been announced but Professor S. A. Courtis, of the University of Michigan, a pioneer in the testing field, is once more trying to start something by inviting school men throughout the United States to join in a cooperative determination of norms for tests of "Mastery of the Combinations" in addition and multiplication.

Professor Courtis' first tests of the combinations in arithmetic, published in 1909 twenty-five years ago, marked the beginning of the widespread use of achievement tests by American school men. His latest creations, announced as the first of a new series of tests based upon a technique called "differential testing," deal with the measurement of precisely the same products of teaching as his original tests. The new tests, it is claimed measure what they measure less ambiguously than previous tests and point the way toward more effective ways of analysis than have been available in the past. If Professor Courtis' claims prove well-founded, very many of the accepted procedures and conclusions in measurement will have to be revised.

It will be exceedingly interesting to watch the progress of this latest attempt to resurrect the measurement movement from the slump into which it has fallen because the great things expected from the scientific study of educational problems have not been forthcoming. Perhaps, as Professor Courtis suggests, the trouble has been with the imperfections of the measuring instruments used, and not with the aims and methods of the movement. In any event, differential testing offers a new avenue of attack upon an old and important problem, and as such is worthy of study by all.

Sample copies of the tests and explanatory statement may be obtained for ten cents by addressing Courtis Standard Research Tests, 1807 E. Grand Boulevard, Detroit, Mich.

SOUTH AFRICAN GRAPES ENTER U. S. WINTER MARKET

Grapes from South Africa will be on the United States market for the first time during the coming winter, thanks to a new pest-eliminating treatment and to a regulation of the U. S. Department of Agriculture permitting fruit so treated to enter. This will give vineyard owners in South Africa the market advantage inherent in the fact that the Northern Hemisphere's winter is the Southern Hemisphere's summer, enabling the shipping of "early" grapes for the American Christmas market.

The embargo that has hitherto been enforced against South African grapes has been due to the danger of introducing the dreaded insect pest, the fruit fly, into the still-exempt American fruit-growing regions. The new treatment consists in exposing the packed grapes to high temperature for a brief period. This eliminates any flies that may be present but does not damage the grapes.